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DWIGHT H. GREEN, Governor

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AFFILIATED WITH THE

ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING

SPRINGFIELD, ILLINOIS

DECEMBER 30, 1944

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ADDRESS OF THE PRESIDENT

RESEARCHES IN LIFE HISTORIES OF PARASITES OF WILDLIFE

LYELL J. THOMAS*
President, Illinois State Academy of Science, 1943-44

INTRODUCTION

Since the beginning of the present war, reports have come into the news about parasites infecting our troops in the tropics. Some individuals perhaps are not exactly sure just what a parasite is. Parasites may be either plants or animals that have found a way to gain their living at the expense of some other organism, their host. This discussion is confined to animal parasites and animal hosts. Parasites are the most abundant animals in the animal kingdom because they have to insure their existence on or in other animals by producing prodigious numbers of their kind. They depend upon their hosts for their livelihood and take just enough of their sustenance so as to keep the hosts living and active until more parasites can be produced.

For the past twenty years I have investigated the life cycles of parasites of wild animals which heretofore had been unknown. It has been my good fortune for the past seventeen years to carry on research and teaching during the summer months at the University of Michigan Biological Station at Douglas Lake, Michigan. There it has been possible to see how parasites live with other wild animals such as fish, frogs, snakes, turtles, birds, and mammals. Wild animals native to this country often harbor parasites transmissible to man or his domesticated animals, or they may serve as reservoir hosts. For example, the broad fish tapeworm of man is also carried by the bear, the wolf, or coyote, while fish serve as intermediate hosts. The lung fluke of man is common in the mink. If man ate the same food as the mink, such as raw crayfish, which is esteemed in some parts of the world, he would be apt to contract lung fluke disease. From the standpoint of animals as carriers or as reservoir hosts it is necessary that we acquaint ourselves with the parasites of wild animals.

In one major branch of the animal kingdom, the Platyhelminthes or flatworms, there are two classes, all of which are parasites, the Class Trematoda, or flukes, and the Class Cestoda, or tapeworms. Among the Nemathelminthes, or round worms, over a thousand have been described as parasites and they may be found living in practically every other major group of animals.

* From the laboratories of the University of Michigan Biological Station and the University of Illinois Department of Zoology.

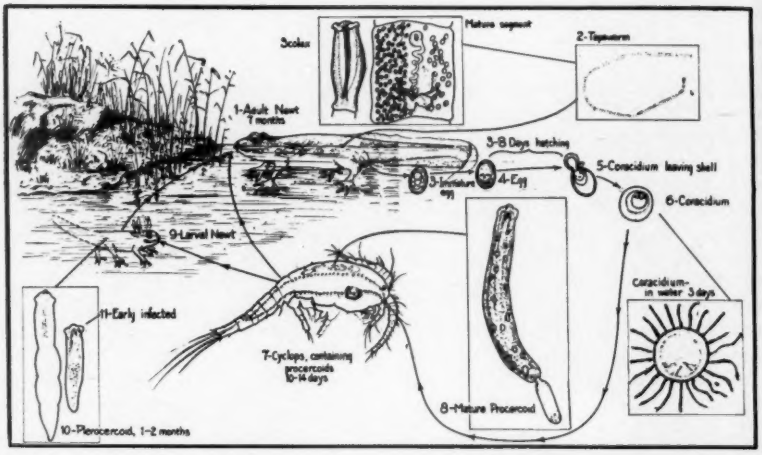

FIG. 1.—*Bothriocephalus rarus* Thomas, a pseudophyllidean tapeworm of the green newt, *Triturus viridescens*. (1) Adult tapeworm scolex and segment. (2) Complete tapeworm from the newt's intestine. (3-5) Eggs passed in the feces of the newt hatch in water in 3 to 8 days; (6) free-swimming coracidum hatched from egg (7) eaten by Cyclops develops within this copepod in from 10 to 14 days into a (8) procercoid in the body cavity of Cyclops; (9) a larval newt eating the infected Cyclops develops (10) plerocercoids within the newt's intestine where in seven months it matures. The larval newt may leave the pond as a red land phase for several months before returning with its tapeworm to the pond. The adult newt may transfer the larval tapeworm to its intestine either by eating the infected larval newt or by eating infected Cyclops.

In order to begin a life cycle study, one must understand the ecology of the hosts or have an intimate knowledge of the relationships of the hosts to their environment, where they live, what food they eat, and what factors influence their choice. One must also be on the alert for each scrap of information obtained and recorded. Information from nature must be taken when presented, otherwise days, weeks, and even years may go by before another such occasion arises.

This I can illustrate in an early attempt to solve a life cycle. The problem I chose seemed to be one that could be easily completed in one summer although I knew little about the host involved.

HOW A NEWT DEVELOPS A TAPEWORM

A small green newt, *Triturus viridescens* (Fig. 1), which lived in numbers in a beach pool had an interesting tapeworm. The newt's stomach contents indicated that it ate small water animals. Eggs passed with the feces hatched in well water at 72° F. within five days. The small spherical ciliated larval tapeworm appeared much like a one-celled animal as it rolled over and over in the water. Small aquatic animals called Cyclops, and relatives of crayfish and lobsters, ate these tiny worms. By examining the Cyclops under a microscope, it was possible to see the young tapeworm use its six hooks to

push intestinal cells aside and to come into the body cavity of the copepod. After several days in this host the six hooks became inactive and the opposite end now began probing movements in the body cavity and functioned as the anterior end. The hooks became constricted into a small tail-like appendage. The body part appeared like the head or scolex end of the adult tapeworm and seemed ready for its next host. Young newts were found to have larval tapeworms and copepods which appeared like the experimental ones. It was now necessary to test this experimentally, and parasite-free newts were required. The surest way to have them free of parasites was to grow them.

Artificial ponds near the laboratory were stocked with water plants and newts from the beach pool, as I thought that in this way I could easily obtain a quantity of eggs and larvae. Much to my dismay, I found a few days later that every newt had disappeared. Many were found some distance from the ponds under leaves, their skins dry and their tails more slender. They just would not stay in water.

The next June, adult females were isolated in aquaria with water plants such as Elodea. One newt was observed laying eggs, small yellowish jelly-like spheres, which she attached singly to the nodes of the Elodea. After forty had been laid I decided to leave her there until the following morning to see how many more she would lay before I disturbed her. The next morning they were all gone, as she had eaten every one during the night. From then on as soon as a few eggs were laid, the newt was transferred to another aquarium. After eighteen days, the young newts hatched and were fed infected Cyclops. By the middle of July they were a brick red and were found climbing up the sides of the aquaria. This same migration was observed in the beach pool across the lake. These young amphibians would come to the water's edge and remain quietly until their external gills dried and then they moved off into the moss and leaves. This migration went on all summer as the adult newts were laying eggs in the pool from late June to late August. Under moist logs in the woods, larger red phase newts were found. They had immature tapeworms and the newts had changed their diet to small earthworms and gnats. By keeping red phase newts over until the following year, it was discovered that their tapeworms remained immature until the newt had changed to the green color phase and returned to the pond.

If adult newts were starved, their tapeworms shed their segments but left the head or scolex attached to the intestinal wall. If infected newts were rapidly changed from cold to warm water their tapeworms would be shed. If the worms were not removed from the aquarium the newt promptly ate and digested them. Thus after several summers' work, it was established that adult newts could become infected by eating infected young newts, by eating infected Cyclops directly, or as young newts become infected,—by eating Cyclops and carrying the infection over through the red phase until they returned to the pond a year later.

I soon learned that several life cycles had to be carried on at one time in order to take care of mishaps which might occur in any one problem and thus leave me empty-handed until another season. The foregoing account of a newt tapeworm cycle culminated in two papers on *Both-*

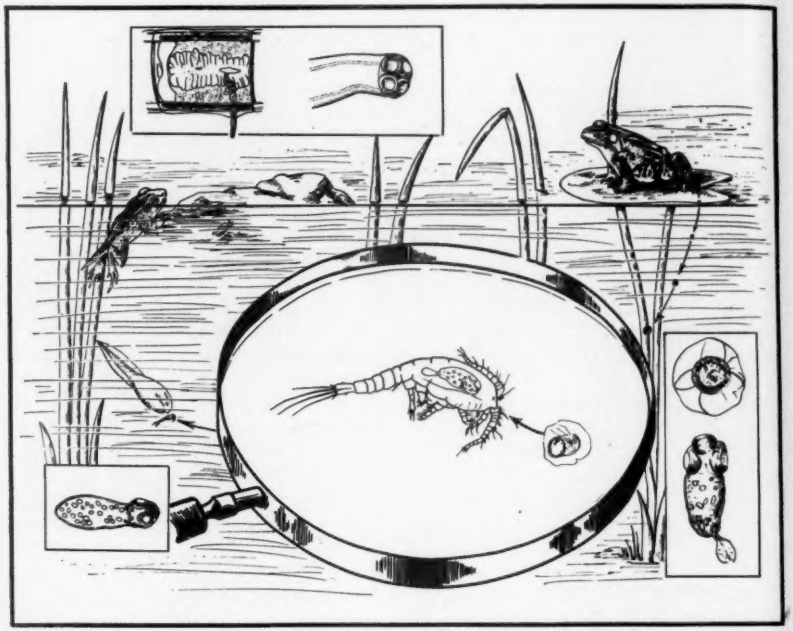

FIG. 2.—*Ophiotaenia saphena* Ossler, a tetraphyllidean cestode from the intestine of the green frog *Rana clamitans*. At top of figure a mature segment and scolex of the tapeworm from the frog. Eggs passed in feces and eaten by Cyclops produce a procercoid (lower right) which if sucked in with the Cyclops develops as a plerocercoid (lower left) in the intestine of a tadpole. By metamorphosis of the tadpole the tapeworm becomes mature in the young frog's intestine.

riocephalus rarus, the first account for any amphibian tapeworm of its kind.

HOW A FROG GETS ITS TAPEWORM

Frog tapeworms also engaged my attention, as nowhere in the literature was there an account of their life cycle. A new tapeworm in green frogs, *Rana clamitans*, was observed (Fig. 2). A heavy infection was found in frogs which lived in a roadside ditch on Burt Lake, Michigan. The work of describing the new worm was given to a graduate student and a paper appeared naming it *Ophiotaenia saphena* Osler. I concentrated upon the life cycle. Cyclops again served as the intermediate host. These little crustaceans would nibble on the gelatinous-covered egg until the larval tapeworm or onchosphere was released, then promptly swallow it. If a gravid segment of the worm was placed in a shallow dish containing Cyclops they were drawn to it as though by a magnet. They pounced upon the segment, ripping it open to get at the eggs. Many would gorge themselves so that due to the large number of worms penetrating their in-

FIG. 3.—*Ophiotaenia perspicua* LaRue, a tetraphyllidean cestode of snakes. The eggs passed in the feces of the snake come into the water where they are eaten by Cyclops (lower right). In this copepod develops a procercoid (middle right) which if eaten by fish or tadpoles develops into an encysted plerocercoid (upper right) in the liver and mesenteries of these animals. A water snake eating an infected fish, frog, or tadpole develops mature tapeworms (upper left).

testinal wall, they were killed. Two weeks were required for the infective stage of the tapeworm, or procercoid, to develop. Laboratory-reared tadpoles sucked up the infected Cyclops and became infected. These immature worms in their intestines developed but slowly. With the metamorphosis of the tadpoles into frogs the tapeworms matured. In northern Michigan, as two years are required for tadpoles to metamorphose, it takes that long for the tapeworm to mature.

In the livers and mesenteries of frogs and mud minnows from this same habitat were other tapeworms which would not mature in the frogs. Water snakes and garter snakes had a tapeworm named *Ophiotaenia perspicua* (Fig. 3), which was abundant in these reptiles from this same general region. Liver and mesenteric cysts, the plerocercoid stage of this worm, fed to laboratory-reared snakes matured in them. Cyclops were infected by feeding on the eggs and the infection was transferred to tadpoles. This was the first completed life cycle of a tapeworm of snakes.

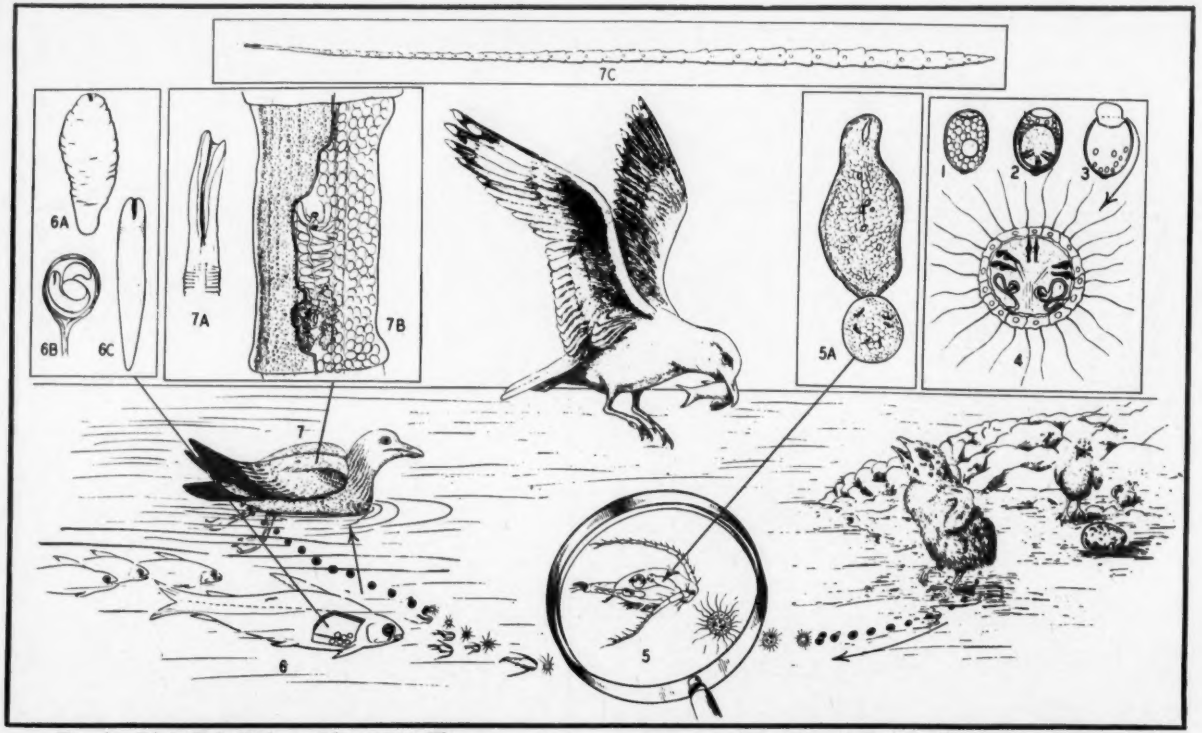

FIG. 4.—*Diphyllobothrium oblongatum* Thomas, a pseudophyllidean tapeworm from the gull. The eggs (1-3) develop a coracidium (4) which hatches in water in 10 to 14 days at 72° F. A Diaptomus (5) eats the coracidium and develops a procercoid (5-A) in 10 to 14 days. Herring or minnows (6) eating infected Diaptomus develop plerocercoids (6-A, B, C) in from 1 to 2 months encysted on the stomach wall or mesenteries. Young gulls fed infected fish by parent birds develop mature tapeworms within one month and shed them.

THE ROLE OF FISH AND MICROCRUSTACEA IN THE LIFE CYCLE OF A BIRD TAPEWORM

A Finnish worker Jarvi (1909) first directed attention to the stomach cysts of a tapeworm thought to be the broad fish tapeworm of man, which infested the herring in the lakes of Finland. For many years I had observed that they were abundant in herring from the Great Lakes. I had also received segments of tapeworms reported to be floating on the waters of Canadian lakes and the Great Lakes as well as Douglas Lake. The general picture of the infestation seemed to indicate a bird as the distributing agent. It so happened that in the course of host examinations in the laboratory, a new tapeworm related to the broad fish tapeworm of man was discovered. I have named it *Diphyllobothrium oblongatum* (Fig. 4) to distinguish it from *Diphyllobothrium strictus*, a tapeworm found by a Russian scientist Theodore Talysin in 1932. His worm found infecting fishermen in the region of Tomsk, Siberia, is a small one 47 cm. long and very similar to *D. oblongatum*. Since the herring gull was found to be infected with *D. oblongatum*, and only young birds at that, it became necessary to make many trips by means of a small fishing trawler to gull rookeries some 40 miles out in northern Lake Michigan to obtain infected birds, as only about 50 percent have the worms. The annual number of fledgeling birds taken over the past eight years is fourteen. This number is small in comparison with the great numbers that are killed by adult birds when the young get out of their territories or by the depredations of crows, or by the elements themselves. On one occasion we were caught on Pismier Island in a violent hail storm with no protection except that afforded by small shrubs about three feet

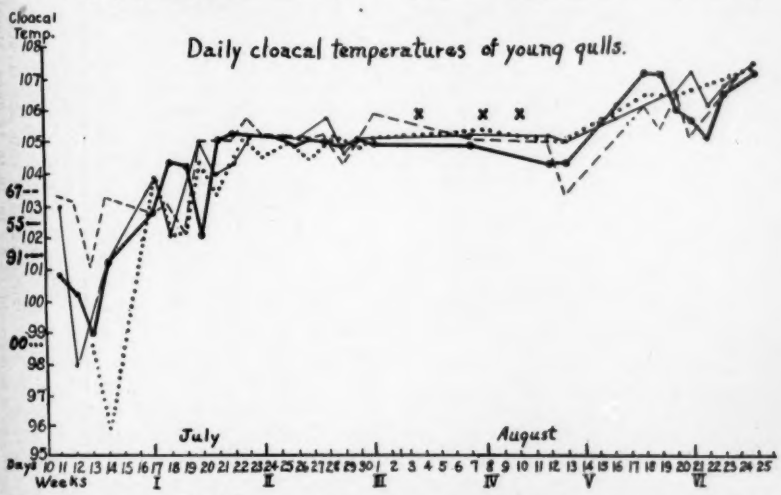

FIG. 5.—Daily cloacal temperatures of young gulls Nos. 67, 55, 91, and 00 fed Diphyllobothrium cysts after hatching in incubator; then birds removed to develop. Dates on which eggs were found in feces marked X. Autopsied on August 25, all tapeworms absent.

high. After the storm it was estimated that about ten percent of the thousands of eggs and young had been destroyed.

Observations on the island disclosed that the old birds fed their young largely on herring and minnows. Early in the summer the herring are near the surface far out in the lake. Later they feed in the shallow waters around the islands where they are taken by the fishermen. The gulls, both old and young, leave the rookeries later in the summer and flock to the inland lakes. Segments of tapeworms were found to be shed on the islands and in their adjacent waters. The herring of Douglas Lake have shown only two cysts in over one hundred fish examined in the past six years although great flocks of gulls are on the lake late in August. The unpublished work of a limnologist, Dr. Robert Campbell, on the vertical migrations of microcrustacea in Douglas Lake have shown that the intermediate host for this worm, *Diaptomus oregonensis,* both old and young, are found in Douglas Lake at a depth of 21 meters (that is, below the thermocline, in the cold water covered by a layer of warm water) where they would be available to the herring. If the tapeworm eggs were deposited in Douglas Lake, the herring should have shown heavy infections according to the number of birds present, as fifty percent of the young birds on the islands were infected.

Young gulls a week or so old and old birds could not be infected by feeding them cysts from lake herring, so gull eggs were obtained and hatched in an incubator at 103° F. Their cloacal temperatures (Fig. 5) were taken in the incubator and were found to be the same as the incubator temperature. The following day, they were removed from the incubator and fed tapeworm cysts. Their temperatures ranged from 95° F. to 98° F. Daily temperature readings were taken for six weeks, and it was found that tapeworm eggs began to appear in about four weeks, shortly after which the worms were shed. During this time the body temperatures of the gulls had risen to 106° F. and 107° F. The young birds were now in full plumage and ready to fly. The mean body temperature of the adult gull is 108° F. These data helped to explain the light infections of herring in Douglas Lake, and why I could not infect the older fledgeling gulls and adults.

A study was made of the development of the tapeworm in Diaptomus. Since this copepod is found in large bodies of water, it proved difficult to maintain for experimental purposes. By taking water in which fish had been kept for some time and then stirring it with a paddlewheel it became conditioned to keep the copepods alive so that they could be maintained in shallow dishes. Tapeworm eggs hatched within two weeks in these same dishes and the copepods became infected. After two weeks in the body cavity of the Diaptomus, these copepods were fed to guppies, small tropical minnows. Within one to two months, well-developed cysts were present on the stomachs and mesenteries of these fish. Further experiments with the eggs kept near freezing temperatures for as long as three years demonstrated that the larval tapeworms or coracidia will live and hatch and infect Diaptomus after that length of time. Eggs that come into the cold deep water of Lake Michigan may have their normal development so delayed as to extend the infection of Diaptomus and herring over many months.

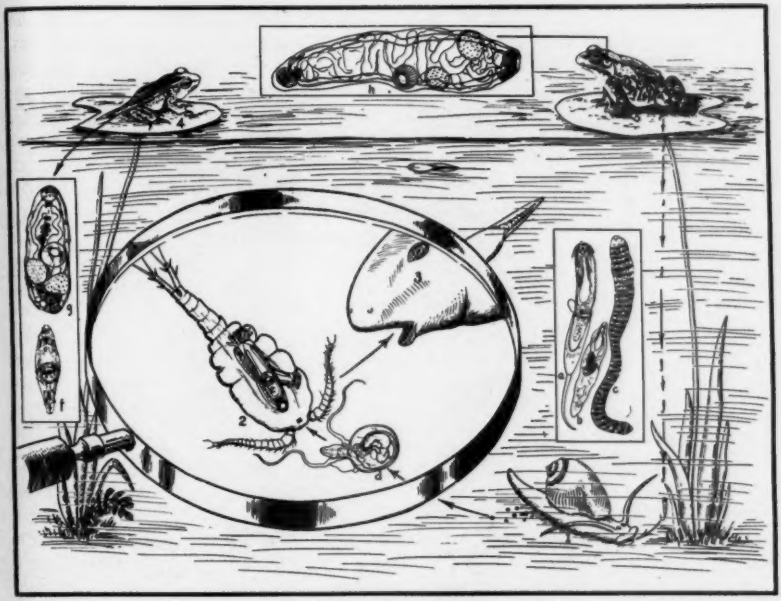

FIG. 6.—*Halipegus eccentricus* Thomas, a fluke from the ears of frogs. Eggs passed in the feces of the frog (1) are eaten by a snail, Physa. Within the snail intestine the egg hatches (a) and sheds its spiny tunic to become a sporocyst (b) just outside the intestinal wall; the sporocyst develops within its body cavity three or more rediae (c) which in turn within a month have 50 or more carcaria (d) encysted in their tails. The Cyclops by eating the cercaria become infected with mesocercaria free in their body cavity in 2 to 3 weeks (2). The frog tadpole (3) sucks up the infected Cyclops and the young flukes migrate from the stomach (f) to the mouth (g); with the metamorphosis of the tadpole (4). The adult fluke (h) finally migrates to the auditory tube in the adult frog (5).

A QUEEN FLUKE IN THE EARS OF FROGS AND HOW IT GETS THERE

Although much of my experimental work at the Biological Station has been with tapeworms and round worms, I found time to work on flukes. Flukes or Trematodes are flatworms without segments and in most of them well-developed sex organs of both sexes are present in the single body. Their life cycles may be very complex and a mollusk such as a snail or clam is necessary as an intermediate host.

Eggs may hatch in the water or in the intestine of the host. The larval stages that occur in the snail are the sporocyst, rediae, and cercariae. The cercariae break out of the snail to infect the next intermediate host, which may be eaten by the final host. In the life cycle of this fluke, *Halipegus eccentricus* (Fig. 6), which I found in the ears of frogs the eggs have spine-covered larvae. Since no cilia for locomotion were present, they had to be eaten by a snail. Snails belonging to the genera Physa and Helisoma proved to be the correct forms. The cercaria shed by the snails were encysted in their own tails. When a Cyclops

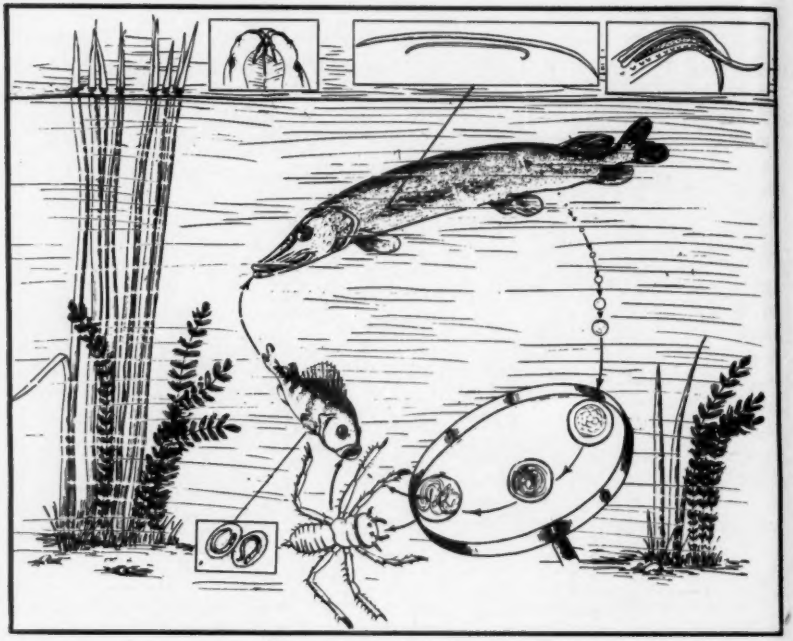

FIG. 7.—*Raphidascaris canadensis* Stafford, a nematode or roundworm from the intestine of the northern pike, *Esox lucius*. The head (upper left) and tail (upper right) of a male worm. The comparative sizes of the male and female worms. Cycle as follows: eggs passed in feces of fish come into the water and develop infective embryos within the egg in 24 hours; bottom feeding minnows feeding on eggs or eating first instar dragonfly which have fed on infective eggs develop liver or mesenteric cysts of this worm. The pike by eating infected perch or minnows gets the adult worm.

touched a release mechanism the larval fluke inside its own tail was shot out into the water by a coiled-up delivery tube. The passage through the tube was so rapid that I missed seeing it entirely in my early observations. The copepod quickly ate the larval fluke which penetrated into the body cavity and in two to three weeks was ready for its next host, a tadpole. With the metamorphosis of the tadpole into a frog, the young fluke traveled from the stomach into the mouth and then into the middle ear. Before this paper came out, Krull (1935) published a similar cycle for the worm *Halipegus occidualis* Stafford. The adult flukes were very similar but the larval stages differed so widely that my specimen had to be called *Halipegus eccentricus*. My delay in publication resulted in the discovery of a new species.

A ROUND WORM IN THE INTESTINES OF PIKE AND HOW IT DEVELOPS

For a number of years the classes in parasitology had been finding round worms, *Raphidascaris canadensis* (Fig. 7), in the intestines of

the northern pike, *Esox lucius*. Masses of eggs would stream from the female worms when placed in water. As they have glassy clear egg shells it was possible for me to observe their development from the single cell stage to an active larva in only eight hours. Within twenty-four hours one molt had occurred in the egg and the larva was ready to infect some host. Encysted stages of the worm were found in abundance in the livers of perch taken from the lake. Fingerling perch, however, were not infected. Guppies were easily infected as they picked the infective eggs from the bottom of the aquarium. It was then discovered that the fingerling perch were plankton feeders, eating only microscopic life near the surface, whereas yearling perch feed near the bottom and on insect life on the vegetation. When eggs were presented to tiny first instar dragonfly nymphs they promptly ate them as they could see the wriggling worms turning about in their egg shells. Normally they eat only moving objects. Older nymphs were too large to see the eggs. Mature nymphs from the lake had walled off the worms in their body cavities with chitin so that unless they were eaten by fish, the worms would eventually die. Infected nymphs were fed to guppies and they in turn to fingerling pike and muskalunge, in which the worms developed normally in their intestines.

A ROUND WORM IN THE STOMACHS OF WATER BIRDS—ITS LIFE CYCLE

It was my good fortune in the fall of 1935 to be on the Rock River, Illinois, where the State Natural History Survey had its laboratory boat. I was interested in the gyrations of the gizzard shad over the surface of the water. Ordinarily they are bottom feeders. Aside from a fungus growth which covered their gills and seemed to be asphyxiating them, they had a number of round worms encysted in their mesenteries. Gizzard shad as a rule have few if any parasites. Since the round worms belonged to a group of nematodes infesting fish-eating birds and mammals and no life cycles were known, I thought this a good opportunity to solve it. Down the river a short distance from the boat, black cormorants were observed roosting in some dead trees. Two birds were obtained and a great number of this same worm, *Contracaecum spiculigerum*, (Fig. 8) were found mixed with the stomach contents of freshly eaten shad. Black bass, crappies, and shad from the region were all infected.

Large numbers of eggs were dissected out of the female worms and incubated in shallow dishes. In about seven days the dishes were filled with rapidly swimming larvae. Two molts occurred in the egg and one after hatching. Thus encased in three protecting sheaths they withstood considerable drying. Guppies ate them avidly so that after one month many fish died because of the growing worms. Chicks and white pekin ducklings given large doses of the worms did not become infected. They did not become infected when given infected fish. I evidently needed fish-eating birds.

The following spring fledgeling cormorants were obtained from the Illinois River. Feeding them presented a problem. Canned mackerel served as food but it had to be crammed by hand down their throats. They would not drink water even though a deep bucket-full was placed in their pen. Then I remembered that they had come from nests high up in trees and that the old birds must water them. A pop bottle of

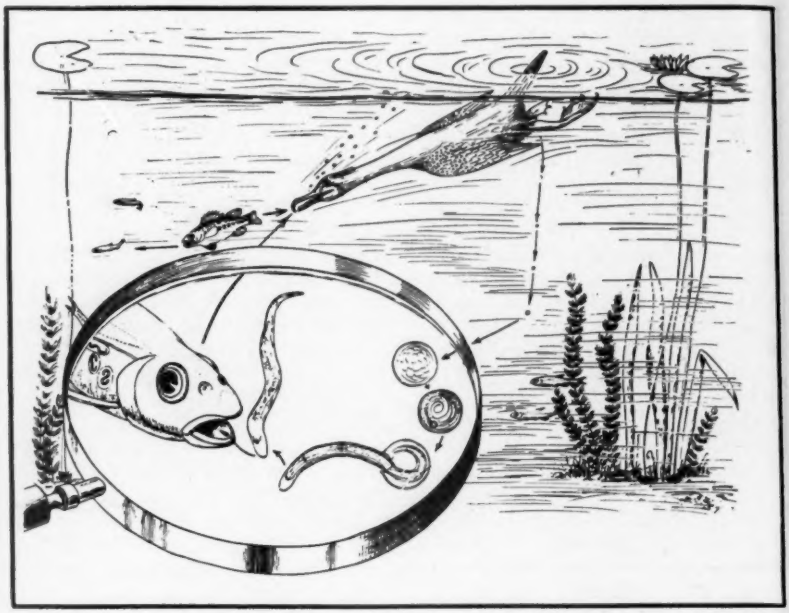

FIG. 8.—*Contracaecum spiculigerum*, a nematode parasite in the stomachs of fish-eating water birds. The eggs passed in the feces of the bird develop in the water and hatch in the water. As the larval worms swim rapidly about they are eaten by minnows. The worms encyst on the liver and mesenteries. The worms may be transferred to other fish eating the infected minnows and these carnivorous fish may be eaten to infect the cormorant or the cormorant may become infected by feeding on infected minnows.

water was soon emptied down each open beak. Thereafter my appearance with a pop bottle in hand was a sufficient cue for the birds to open their beaks and to set up a loud clamor sounding much like many doors opening on rusty hinges. Ten of the birds were given a treatment of carbontetrachloride to remove any worms fed to them by their parents. The worms were found to bury themselves in the stomach glands between meals and to come out and penetrate into the digesting food at meal time. Two of the treated birds used as controls were not fed infected guppies and had no worms when examined. After one month eight birds were shipped to Douglas Lake and the feeding of infected guppies was continued with the four that survived the trip. Three of them were sacrificed the latter part of August, and worms in different developmental stages were recovered. The fourth bird, a little male called Oscar, bebecame such a pet that I turned him over to the Ann Arbor Zoo. Oscar was allowed to fish for himself on the lake but if he saw some one carrying a bucket or a pan he would fly in to shore hoping to get a free meal. As long as he was at the lake,

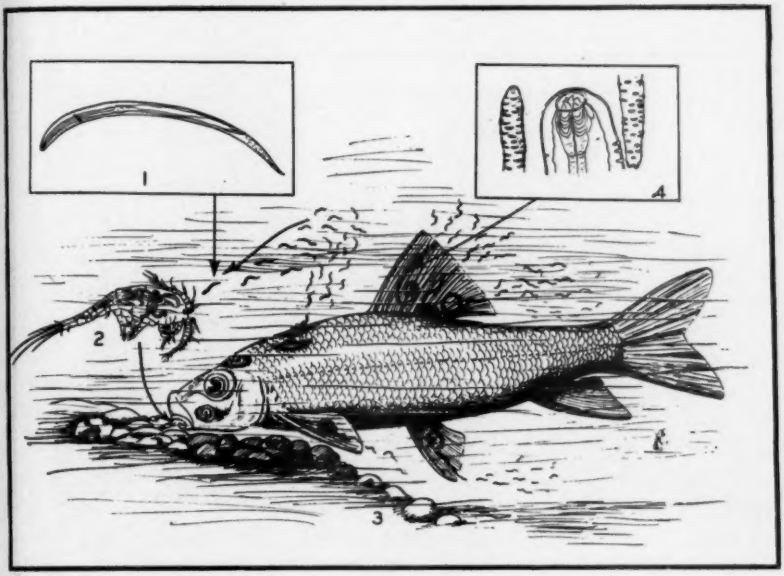

FIG. 9.—*Philometra nodulosa* Thomas, a dracunculid-like round worm parasitic in the skin of fish, *Catostomus catostomus*, etc. Larval worms (1) escaping by rupture of the fish's skin are eaten by Cyclops (2) where they mature to the infective stage within 2 weeks. Fish eating these copepods have the female worms (4) appearing in the skin within a year.

he returned to his pen at night to roost.

Contracaecum spiculigerum, this round worm parasite of cormorants, was found to be well adapted to its host and to adverse environmental conditions. Its eggs were frozen in ice in October and when thawed out the following March hatched 100 per cent. Guppies were infected with these larvae. It is therefore possible for eggs left in the late autumn to remain dormant until spring when they will hatch and infect fish, which in turn will infect birds.

HOW FISH, LIKE MEN, MAY HAVE A GUINEA WORM

In Sturgeon Bay, upper Lake Michigan, the most common sucker taken by fishermen is the red-horse, *Catostomus catostomus*. Quantities of them are shipped undressed or "in the round," as the fishermen say, packed in ice and sent to the New York market. During the latter part of June and the first part of July many are disfigured for the market by the presence of blister-like patches containing bright red round worms (Fig. 9). The worms are most abundant in the skin in the head region and in the dorsal and pectoral fins. This worm I described as *Philometra nodulosa*. It is a close relative of a worm infecting man which is found in Africa, around the Mediterranean, and in India. There it appears on the legs or backs of water carriers and is known as the Guinea Worm. It is thought to be the "fiery

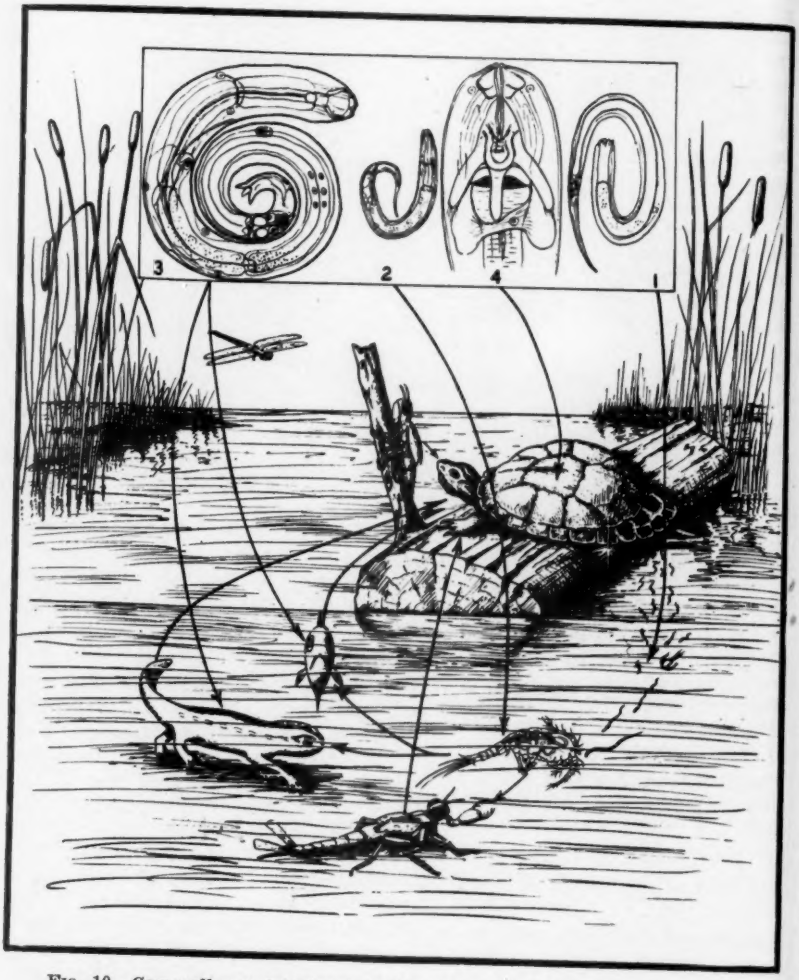

FIG. 10—*Cammallanus trispinosis* Leidy, a nematode inhabiting the small intestine of turtles. The female worms are ovaviviparous, the larval worms pass out with the feces (1) and are eaten by Cyclops. After two molts in the body cavity of Cyclops (2) within two weeks, if eaten by damsel fly or dragonfly nymphs, or newts, or salamander larvae, the worms (3) attached to the intestinal wall may infect turtles. In fish the worms burrow into the mucosa and infect turtles which eat them.

serpent" of the Children of Israel according to the biblical account. Like its relative the Guinea Worm, the breaking of the blister releases myriads of larval worms into the water where they are eaten by Cyclops. The young worms penetrate into the body cavity of the copepod and arrive at the infective stage within two weeks. Suckers feeding on the lake bottom pick up the now sluggish Cyclops. Fish examined late in December had males and female worms in the heart region. Late in June the female worms appear in the surface tissues filled with motile larvae but no males seem to be present. It has been recorded from black bass in an Illinois fish hatchery and in fish from Oneida Lake, New York.

THE PART PLAYED BY OTHER ANIMALS IN THE LIFE CYCLE OF AN INTESTINAL WORM OF TURTLES

The work of Rudolph Leuckart on Cammallanus, a nematode parasitic in the intestines of fish and turtles, clearly demonstrated that Cyclops were the intermediate hosts. This discovery led to the demonstration of the life cycle of the Guinea Worm of man by Fedtschenko in 1871. There were certain so-called free-living stages in the life cycle of Cammallanus that could not be accounted for.

A famous American physician and parasitologist of the past century, Joseph Leidy, described a worm from turtles, *Cammallanus trispinosis* (Fig. 10), which is the subject of this life cycle. The adult worms are a bright red color and are provided with true jaws which clamp on the intestinal epithelium. Each female produces hundreds of motile larvae which come into the intestinal lumen and pass out with the feces. In the experimental dishes they generally attached themselves to the bottom and coiled and uncoiled until eaten by a Cyclops.

After two weeks in the body cavity of a Cyclops they are ready for a second intermediate host. Damsel fly and dragonfly nymphs as well as young salamanders, newts, and fish were used for this purpose. The worms attached themselves to the intestinal wall of the insects and amphibians by means of their cup-like mouths and showed no further development after two weeks in this location. In the intestines of fish they buried themselves in the mucosa.

As more infected Cyclops were fed to damsel fly and dragonfly nymphs some of the worms passed out into the dishes in which they were kept. These worms remained active in the water for as long as three weeks. This helps to explain why some workers believed that there was a free-living stage in the life cycle. An examination of turtles in nature has shown identical worms in their intestines. These turtles can get their infection from eating nymphs, salamanders, or newts which have the young in their intestines.

In the spring of 1935 while examining the intestine of a spoonbill catfish, *Polyodon spathula*, I found large masses of these worms imbedded in the mucosa. Chunks of the intestine containing the worm were cut out and fed to three painted turtles on March 18, 1935. Previously to this the three experimental turtles and three controls were given a carbon-tetrachloride treatment to eliminate any possible natural infection. Three months later when all turtles were autopsied, the controls were negative for Cammallanus but the experimental ones had masses of adult worms.

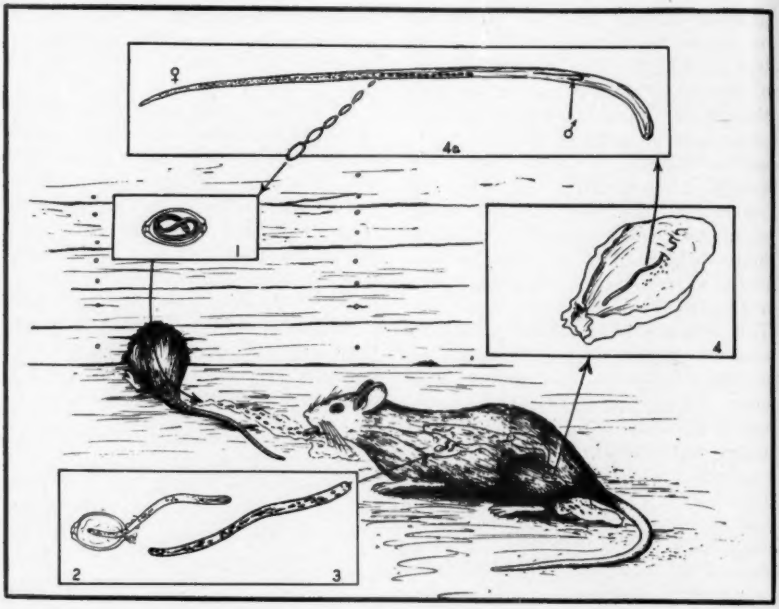

FIG. 11.—*Trichosomoides crassicauda* (Bellingham), a nematode which sews itself into the epithelial lining of the urinary tract of rats. Eggs passed in the urine are fully embryonated (1); hatching (2) in the digestive tract of the rat, the larvae (3) migrate through the body of the rat to become egg-laying adult females in 3 to 6 weeks sewed into the urinary bladder wall (4) while the male retaining many of its larval features wanders about and enters the female uterus (4-a) to complete copulation.

RATS AND THEIR RELATIONSHIPS TO ROUND WORM PARASITES

Rats are vectors or reservoir hosts to a number of helminth parasites found in man. *Trichinella spiralis* is a round worm commonly associated with cysts in pork which if eaten by man produces the disease known as trichinosis. It is estimated that over 10 percent of our population are carrying in their muscles the little cysts of Trichinella, having at some time eaten a few encysted worms in underdone pork. As there is as yet no known cure for the disease once acquired, and a heavy infection will kill the host, its prevention is the only safeguard. Cook all pork well before eating it.

Capillaria hepatica is a round worm parasite of this same group living in the livers of rats and mice, the muskrat, the beaver, the North American prairie dogs, and the peccary. Transfer to man may be made by eating infected livers not thoroughly cooked, or by the disintegration of the host, the eggs then picked up through contamination of food or drink. The worm produces a marked cirrhosis of the liver.

Trichosomoides crassicauda (Fig. 11) is another of these round worm parasites of the rat which lives sewed

into the urinary bladder, the ureters, or kidney capsule. One of my first life cycle experiments was the study of this parasite's migration through the body of the rat. The eggs are passed in the urine and are fully embryonated when laid; when ingested in food or drink the larvae hatch and pass into the body cavity or circulatory system by means of their stylet, a sharp spear-like organ in the mouth cavity. Only those that arrive in the kidney will mature. The males are extremely small and retain many of their larval characteristics, including the stylet. They move freely through the tissues of the host while the female loses its stylet early and sews itself into the epithelial wall of the urinary tract. Most of the males are commonly found living in the uterus of the female worm. Infection then is direct and most rats show eggs in their urine in from three to six weeks after ingesting the eggs. One of my students working on an immunity problem with this worm has recently found a method for early diagnosis of the worms before eggs appear which may be applicable to the early diagnosis of human schistosomiasis.

FUTURE NEEDS FOR FUNDAMENTAL RESEARCH ON THE PARASITES OF WILD ANIMALS

There are those who believe that unless research is directly applicable to medicine it has no intrinsic value, but the foundations for the understanding of human helminthology have all been laid by the researches in parasites of wild or domesticated animals.

After this war and while men are returning from overseas service in parasite-infested centers throughout the world, certain diseases more or less new to this country may make themselves known. Filariasis, or more specifically "filarialelephantiasis" and "onchocerciasis," may become established more generally in the United States. Its worldwide distribution lies well below the 40th parallel north latitude and not beyond the 40th parallel south latitude. In Charleston, South Carolina, a small endemic center has been established since slave days when it was undoubtedly brought over from Africa. It is well established in the Caribbean and Central American countries.

Wuchereria bancrofti microfilaria are small round worms which circulate in the blood stream while the adults are confined to the deep lymphatic tissues. These lymphatics become greatly dilated when the worms are present in numbers. In occasional cases other lymph glands become involved such as those of the scrotum, inguinal glands, and mammary glands with huge enlargements of the legs known as elephantiasis. Another species *Onchocerca volvulus* with unsheathed larvae of two sizes resides only in the skin and produces nodules about the head region. The larvae may migrate into the eyes causing blindness. This type is more prevalent in Guatemala, whereas a body or leg inhabiting species is found in Africa. *Wuchereria bancrofti* is carried by several genera of mosquitoes all of which are present in the United States. *Onchocerca volvulus* is transmitted by blackflies belonging to the genus Simulium, a widely distributed gnat in this country. Culbertson and Rose working with filaria in cotton rats last March reported a drug neostam, which may well prove to be a cure for human filariasis.

More malignant, fatal malarias such as *Plasmodium falciparum* and *P. malariae* may also be brought in by war prisoners and returning soldiers. Here may be found all of the

anophelene mosquito vectors necessary for life cycles and distribution. It does not necessarily follow that we may expect wide epidemics of tropical diseases, but that medical men should become well versed in parasitology and tropical medicine, that more research attention be directed to the parasite diseases of native wild animals which may serve as vectors or reservoir hosts of these parasitic diseases.

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AGRICULTURE

HAIL DAMAGE TO SOYBEANS

Report of 1943 Results

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Considerable interest has been evident in recent years in the results obtained from experiments with soybeans artificially injured to simulate hail damage. Damage by natural hailstorms to soybeans is of more than passing interest to insurance companies that underwrite farm crops. Soybeans are a comparatively new crop in the United States; their history dates back only to the early years of the present century. Likewise hail insurance of the soybean crop is only a few years old.

The problems of insurance companies in underwriting soybeans are similar to those first encountered with cotton, corn, and other crops. Adjustments of losses of these crops could not be made by any rule-of-thumb method. Most adjusters will agree that this is still true for the most part, although a considerable "bank" of experience is now available upon which adjusters may draw. However, this is not true of soybeans. Adjusters are still dependent upon trial-and-error methods, always hoping that they will not be too far off in their results. Fortunately, past experiences with other crops have been of tremendous assistance in arriving at an equitable figure in making adjustments of claims.

PREVIOUS WORK

During the past three or four years the Illinois Agricultural Experiment Station has tried to ascertain the factors attending various degrees of hail damage to beans. In cooperation with Mr. L. G. Van Zile[1] some field work was begun in 1942 at Urbana. Unfortunately not enough beans of any single variety were available in a sufficiently large area to provide an adequate number of replicated samples to carry through the entire season. The results obtained by using some seven or eight varieties were confusing, but followed a definite trend. This trend was toward sharply decreased yields following the flowering period and very drastic reductions when plants were damaged during pod formation and filling. These results were as expected. However, the number of varieties used made it difficult to definitely relate the date of damaging to the estimated amount of damage. Previous to this some work by G. H. Dungan et al[2] indicated a similar trend.

Greenhouse plants are not entirely satisfactory for hail damage experimental work. One of the most important factors affecting soybeans in greenhouse work is light. Plants tend to grow spindly and produce only a fraction of the flowers and pods ordinarily coming from a normal plant. Insects also are more serious

[1] Special agent for the Rain and Hail Insurance Bureau, Chicago, Illinois.
[2] Unpublished data.

TABLE 1.—SUMMARY OF DATA FROM HAIL DAMAGE PROJECT—ARTIFICIAL DAMAGE OF RICHLAND SOYBEANS.
(Planted June 7, 1943—Urbana, Illinois)

	Dates of Defoliation						
	June 29	July 12	July 19	July 24	Aug. 11	Aug. 26	Sept. 6
	bu/A	bu/A	bu/A	bu/A	bu/A	bu/A	bu/A
			30% Defoliation				
	36.0	35.9	29.4	23.6	18.1	17.4	11.1
	25.1	27.5	27.4	29.5	15.6	20.0	10.1
	26.2	27.9	30.3	29.4	16.2	17.4	14.7
	32.6	33.7	22.4	28.6	12.3	14.7	.....
Average.....	29.9	31.5	27.4	27.7	15.6	17.4	12.0
Standard Deviation.....	4.8	3.6	3.0	2.4	2.0	1.9	1.9
			50% Defoliation				
	26.4	27.7	27.4	25.8	8.2	10.4	9.9
	29.0	31.3	25.5	22.6	11.2	13.8	11.0
	28.1	25.0	29.9	29.0	11.3	12.7	8.7
	36.3	29.5	27.0	22.4	10.2	11.6	10.8
Average.....	29.9	28.2	27.4	24.8	10.2	12.0	10.1
Standard Deviation.....	3.8	2.3	1.6	2.6	1.2	1.3	0.9
			75% Defoliation				
	24.5	23.4	.....	11.0	4.6	6.1	7.9
	24.8	24.4	.....	17.7	18.2	5.8	4.7
	19.4	27.4	.....	20.5	6.2	5.5	1.5
	24.6	23.0	.....	16.2	8.3	10.3	.....
Average.....	23.2	24.6	.....	16.3	9.3	6.9	4.7
Standard Deviation.....	2.3	1.7	.....	3.4	5.3	1.9	2.2

in the greenhouse. All of these factors and many more limit the value of greenhouse work to studies of comparative results. Treatments designed to determine the recovery of plants, bud reproduction, and other botanical phenomena are of some value.

WORK IN 1943

In the spring of 1943, Richland soybeans were drilled in 24-inch rows for these studies. Although planted late (June 7) the stand was good and growth rapid. Three levels of defoliation were decided upon. These were carried out on seven different dates throughout the growing season: namely, June 29, July 12, July 19, July 24, August 11, August 26, and September 6. Random rod-row samples were defoliated. Percentages of defoliation were approximately

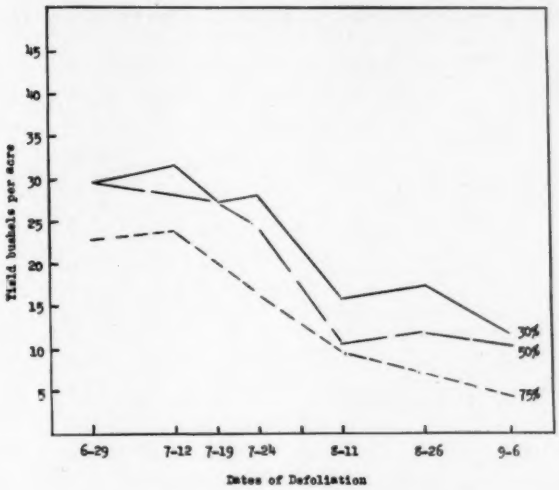

FIG. 1.—Yield of soybeans as a result of different degrees of defoliation.

30, 50, and 75, the latter entailing very rough handling, breaking of stems, etc. Insofar as was possible most of this work was carried out during the morning of the day selected as the somewhat cooler temperatures at this time of day more closely approximate conditions prevailing just prior to or during hailstorms. All defoliation was by hand as contrasted to the use of various devices in preceding years. Pertinent data are presented in Table 1 indicating yield by rows and averages in bushels per acre. Standard deviations are included.

If desired, statistical analysis can be applied, although the advantages of further statistical subjugation of these data are questionable. Figure 1 presents the same data graphically. Some question may arise as to differences seeming to favor increased yields on July 12 over June 29 under 30 percent defoliation. A comparison of the deviations will serve to clarify these figures, for the deviation of June 29 is sufficiently large to approximately equal the yield plus deviation of July 12. Table 2 indicates the final yield of Richland beans that were not defoliated.

TABLE 2.—YIELDS OF RICHLAND SOYBEANS FROM UNDAMAGED SAMPLES—1943

Sample	Yield
	bu/A
1	37.4
2	27.5
3	28.2
4	27.9
5	23.0
Average	28.8
Standard Deviation	4.7

OTHER RESULTS BEARING ON HAIL DAMAGE

One of the methods of adjusting losses caused by hailstorms is that of sampling fields and estimating

TABLE 3.—AVERAGE NUMBER OF SOYBEAN PLANTS PER ROD ROW AND AVERAGE YIELDS FROM 1/20-ACRE PLOTS. URBANA, ILLINOIS—1943.

Variety	Number of Plants Per Rod Row		Yield
	July 2	July 30	
			bu/A
Earlyana	78.5	79.0	23.0
Richland	85.5	81.3	24.9
Mingo	82.8	69.5	28.5
Mukden	121.0	117.8	26.4
Dunfield	108.5	112.3	27.5
Lincoln	85.5	102.0	29.4
Illini	160.5	157.7	26.8
Patoka	104.3	111.5	29.8
Viking	80.7	87.7	28.9
Mt. Carmel	111.0	105.7	30.6
Chief	185.5	170.0	28.1
Gibson	190.3	220.0	31.2
Ebony	210.0	179.7	12.2
McClave	.....	210.3	19.9

losses based on the estimated percent of damage on a given number of plants. This brings with it the question of how many plants constitute a "stand." This is difficult to answer. Stand counts will differ with varieties on the same field. However, within reasonable limits the number of plants in a given area can differ widely and still produce at a similar rate. Table 3 gives the results of stand counts made on two different dates at Urbana and the average acre yield of beans from these plots.

Although no conclusions can be drawn at the present time from these experiments, certain definite trends are observable; namely,

1. Light hail damage during early-growth periods and previous to blossoming does not depress yields. Heavy hail damage during this same period does reduce yields very materially.

2. Severe reductions in yields resulted from all rates of defoliation during the period of pod formation and filling—August 1 to August 15, 1943.

3. The results obtained this season using Richland beans may be expected to differ slightly from other varieties which may vary in time of flowering and pod formation. However, it is considered probable that the relative yields would vary but little.

ILLINOIS FOREST FUTURE

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Illinois needs a definite forest policy on which there is substantial agreement by all the agencies and individuals who are directly and indirectly concerned with the future of Illinois forests. Such a policy should be formulated at the earliest possible date and be published as a guide to future developments. Only on the premises set forth in such a policy statement can the specific activities of all agencies be properly oriented and fitted into a coordinated program for the development of the forest resources of the state. Some of the factors that must be taken into account in formulating a policy and launching development programs follow.

FOREST FACTS

The forest situation in Illinois has been studied from time to time over a period of at least forty years. These studies have resulted in the publication of papers and reports which generally recommended specific programs and in some instances proposed the elements of a forest policy. Some of these programs have been put into operation. As a result progress has been made in restoring and improving the forest resource, but there is still need for broad scale planning as well as detailed study of specific forest problems.

As determined by the Illinois Soil Survey and the Illinois State Natural History Survey, more than fifteen and a quarter million acres, or approximately 42½ per cent of the state was forested originally. This forest resource was invaluable to the early settlers for fuel, and for fencing and construction materials, in spite of the fact that often the great volume of timber resulting from clearing the land for agriculture could not be utilized. Only after thirty years of settlement and forest clearing was the agricultural value of the unforested prairie land discovered. Timberland adjacent to prairie areas was at a premium during the period of most rapid settlement. There were no facilities for shipping in timber from adjoining states. Wood to build and to warm prairie farmsteads had to come from areas nearby. Where prairie land sold for five dollars an acre, woodland commonly brought thirty-five dollars.

Now, after one hundred and forty years of forest destruction, the forest area of the state has been reduced from 15½ million acres to 3½ million acres. Much of the original forest land should never have been cleared. There is general agreement that a part of it must be returned to timber if it is to become an asset rather than a public liability. A beginning has been made—reforestation is under way. Further study is required to determine the specific areas of cleared land which should be returned to forest, but 2½ million acres would be quite generally accepted as a minimum. Thus the combined present forested area and that to be reforested is at least six million acres—more than one-sixth of the area of the state. It is essential to our economic and social welfare that this land be made fully productive.

Wood is still essential to agriculture and industry. In 1926 the Na-

tural History Survey stated: "In the single item of lumber Illinois consumes one-thirtieth of the total lumber cut of the world." In the aggregate, wood is not being displaced by other materials. New processes and products create an ever increasing demand for wood in industry. Nearly all of the lumber used in Illinois is now brought in at high freight cost from distant points. There is no assurance that these sources will continue to furnish adequate supplies.

Recent studies indicate that the productive capacity of Illinois woodlands has been quite generally underestimated. Full use of our present timberland would provide more than the annual requirement of the manufacturing industries of the state which in 1940 used 580 million board feet of lumber. Importation of certain species which will not grow in the state would still be necessary, of course. The native woodlands are almost exclusively hardwood (deciduous) species. The open areas available for reforestation include 300,000 acres of sand which is suitable for pine. Our studies indicate that this land is capable of producing 500 to 1,000 board feet of lumber an acre each year. Hundreds of thousands of acres of heavier soils in northern and southern Illinois may also be planted to pine.

Illinois gains relatively little benefit from the employment and payrolls involved in the harvesting, processing, and shipping of the timber which she must import. As has just been indicated, we have in the six million acres best suited to timber production a resource, which, if properly developed and managed, can go far towards meeting future timber needs while furnishing profitable employment to a large number of our citizens. Carefully kept records show that sixty acres of well-managed forest of the type that can readily be grown on this land, furnish one man employment in the woods or a primary manufacturing plant for 240 days a year. On this basis, 6,000,000 acres are capable of furnishing profitable employment for 100,000 wage earners directly engaged in the forest industries. If the dependents of these workers are taken into account, this area is potentially capable of supporting more than a quarter of a million Illinois citizens; or of providing supplementary income to a much larger number on a part-time basis.

Among the profitable crops now being produced in Illinois woodland are fuelwood, fence posts, mine timbers and ties, fiber and chemical wood, pulpwood, cooperage staves, handle bolts, veneer logs, and all manner of lumber and timbers for home use on farms and for industrial use. Better management of the existing timberland will frequently treble or quadruple the present rate of timber growth. Even under these circumstances the value of maintaining thrifty forests on land not used for other purposes may not be primarily in the timber crop. The conservation of soil, water, and wildlife are inseparably linked with the maintenance and expansion of our woodland acreage. The importance of forests in meeting the public recreational needs is quite generally recognized. Fortunately the various uses to which forest land may be put are not mutually exclusive. Individuals or the public may own forest land primarily for one purpose, but under a plan of intelligent management, secure several or all of the benefits of forest cover.

WHO SHALL OWN THE FOREST LAND?

Private ownership: Most of the land now in timber, as well as much

of that to be reforested, is now a part of farms. Where this land is associated with sufficient land of real agricultural value it will undoubtedly remain in farm ownership. It should be developed as an integral part of the farms on which it occurs. The outlook for these areas is most hopeful. Experience has amply demonstrated that good management of existing woodland and investment in reforestation will yield satisfactory returns to farmers. The guidance and assistance needed by inexperienced owners can readily be provided by the expansion of programs which already have proved successful.

Unfortunately much of the present woodland and most of the cleared land useful primarily for timber production, though now in farm ownership, is not intimately associated with good agricultural land. Whole groups of farms include little or no productive crop land. There is no adequate source of income from agriculture to support individual owners or the community while timberlands are being rehabilitated and reforested areas are developing merchantable timber. There is no local source of funds for reforestation. Limited areas of this type will pass into nonfarm private ownership for hunting and other recreational uses where the funds for maintenance and development originate outside the local community. Other areas may pass to industrial owners who now hold forest land, particularly that which is associated with mineral and water resources. New types of industrial ownership may arise. Industries such as basket veneer mills may acquire timberland to assure their future supply of logs. Industrial ownership for forestry purposes can be encouraged and technical assistance can be provided for this type of development. The profitable development of private forestry should be aided in every way possible.

Public ownership: It appears unlikely that private ownership, even with the utmost encouragement and assistance, can solve the problem of our non-agricultural land. A large program of public acquisition, development and management seems inevitable. Even the most zealous proponents of private enterprise recognize the necesity of public ownership of some classes of forest land. This ownership may be predominately federal, state, county or community. All these types of public ownership now prevail in Illinois. The total area which will need to be in public ownership is unknown but an immediate minimum program for each type of ownership is needed.

The principal areas in federal ownership are administered by the U. S. Forest Service, the U. S. Army Engineers and the Soil Conservation Service. The Shawnee National Forest, administered by the Forest Service, now includes 200,000 acres. Present plans provide for more than doubling this area through future purchases in ten southern Illinois counties.

The acquisition of land by the state and its development as state forests are a major factor in the forest policy of many states. In fact many states are meeting their idle land problems primarily in this way.

Three state forests have now been established. Their purchase and development is providing valuable experience to guide future programs. That idle land can be acquired, developed, and administered efficiently by the state for the public good is being demonstrated in many parts of the country. There is ample evidence that, on the basis of lumber

value alone, long-time returns will show a profit to the state.

When New York State was considering a great program for the retirement of submarginal farm land by purchase for state forests, her agricultural economists held that the investment would be justified even though not one penny of revenue ever came to the state from these lands. Their justification was in the saving of human misery and public expense occasioned by the hopeless struggle of those who were induced to purchase submarginal farms and invest their savings in repairs to buildings and in equipment. Under its reforestation plan New York bought 200,000 acres between 1929 and 1934. If all costs including purchase, planting, fencing, protection from fire, insects and disease, and all overhead and supervision costs at the state and district level are distributed over the 200,000 acres, the total investment in establishing this state forest was twelve dollars per acre. The program was financed through the authorization of a bond issue of $20,000,000 which allowed twenty dollars per acre to purchase and develop a million acres.

Many states have provided that tax delinquent land be forfeited to the state or county or that it be sold promptly at public auction. These procedures have brought much idle land suitable for forestry into public ownership.

Counties, municipalities, and schools may acquire land for forestry purposes. All these classes of ownership are represented in Illinois. Two or three years ago Illinois gained national recognition for its activity in establishing community forests, but the accomplishment to date merely points the way to larger programs which must follow. The record of the development of community forests in this and other countries deserves careful study as a basis for planning in Illinois.

CONCLUSIONS

Illinois needs a definite forest policy.

There are at least six million acres in Illinois which should be devoted to timber production.

Intensive use of the area available for forestry will furnish profitable employment for many wage earners.

Agriculture and industry in Illinois will continue to require large volumes of forest products.

Existing woodland and plantable areas intimately associated with good agricultural land should be developed and utilized for the production of wood as an integral part of the farm enterprise.

Much timberland and most of the submarginal open land occurs in large blocks where it cannot be included in farms. Limited areas may be held for forestry purposes by individuals and industries.

Public ownership of large areas seems inevitable. Federal, state, county, municipal and school forests all have a place in the picture.

There is need for detailed study of many factors involved in making the potential forest area of Illinois fully productive.

SOME DEVELOPMENTS IN WARTIME AGRICULTURAL PRODUCTION IN ILLINOIS

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There are always important changes in agricultural production during wartime, but they do not always follow the same pattern. Labor and machinery shortages have become major farm problems in this war. Feed and food supplies were much more plentiful at the beginning of the present war than they were in World War I. There is greater recognition now of the importance of conserving natural resources. Greater strides have also been made in producing increased and more effective returns than in the last war.

Agricultural production in Illinois falls into two important divisions, crops and livestock. Important changes in Illinois crops during the present war period include marked increases in the total acreage devoted to major crops, particularly in the combined acreage of soybeans and corn, with decreases in small grain and tame hay (Table 1).

During World War I a larger acreage was devoted to important crops at the beginning of the war than was the case in the present war, 19,721,300 acres in 1915 compared with 17,880,000 acres in 1940. The 20,425,000 acres included in the goals of the listed crops for 1944 is practically the same as the 20,410,000 utilized in 1919. This fact may indicate that this figure is close to the desirable maximum.

The important difference between the two war periods, so far as agriculture is concerned, is the reversed emphasis on small grains and corn and soybeans. Small grains increased from 37.2 per cent of the total of important crops in 1915 to 43.1 per cent in 1919; in 1940 they represented 28 per cent of the total, and the 1944 goals call for 23.6 per cent, or only about 55 per cent of the 1919 acreage. Wheat is the small grain crop which is chiefly concerned. The supply of wheat, both in the United States and in the entire world, was small at the beginning of World War I and was exceedingly large at the beginning of the present world war. Total feed supplies in the United States were also large at the beginning of this war.

With the development of soybeans as an important crop in Illinois, both oats and corn decreased in acreage to make room for them. The soybean acreage of 1944 is expected to almost double the 1940 acreage. This situation is partly the result of a demand stimulated by the loss of Far East vegetable oils and partly of an increased demand for protein meal. Corn is also increasing in acreage as the war continues and feed supplies become shorter, and the 1944 acreage may approach that of 1915.

Another important change in crop production has been the marked increase in yields of certain major crops. Corn yields increased 25 per cent during the nine-year period 1935-43 over the 1915-23 period. The year 1917 was the first year for which Illinois soybean yields as grain were determined. The soybean yield for the 1935-43 period increased 75 per cent over the 1917-23 period. For

TABLE 1.—IMPORTANT ILLINOIS CROP ACREAGES HARVESTED, 1916, 1918 1919, 1940, 1943 AND 1944 GOALS.*

Crop	1915	1918	1919	1940	1943	1944 goal
All corn	9,500,000	9,650,000	8,650,000	7,645,000	8,532,000	9,000,000
Soybean grain	300	2,400	3,000	1,995,000	3,444,000	4,000,000
Oats	4,340,000	4,600,000	4,291,000	3,090,000	3,427,000	3,125,000
All wheat	2,850,000	2,900,000	4,103,000	1,745,000	1,018,000	1,500,000
Rye	90,000	237,000	235,000	49,000	62,000	50,000
Barley	66,000	250,000	177,000	117,000	91,000	150,000
Tame hay	2,875,000	3,200,000	2,951,000	3,239,000	2,607,000	2,600,000
Total	19,721,300	20,839,400	20,410,000	17,880,000	19,181,000	20,425,000
Corn and soybeans	9,500,300	9,652,400	8,653,000	9,640,000	11,976,000	13,000,000
Small grain	7,346,000	7,987,000	8,806,000	5,001,000	4,598,000	4,825,000

* Federal and state crop and livestock reporting service.

the two nine-year periods, wheat and hay showed seven and fifteen per cent increases respectively for 1935-43 over 1915-23. The increase in yields being obtained during the present war period is due to the development of higher yielding varieties, to the improvement of soil fertility and cultural practices, and to favorable weather.

Hybrid seed corn has probably added as much as eight bushels to the yield of corn in Illinois. The AAA figures for the state on farms growing both open-pollinated and hybrid corn showed 6.8, 10.2 and 27.7 bushels increase respectively for all farms reporting for 1939, 1940, and 1941. It should be mentioned that as hybrid seed use increased, a larger proportion of the open-pollinated acreage was found in southern Illinois, and part of the difference in yield in 1941 was due to difference in soils. Corresponding data for crop reporting district 6 (east central Illinois) showed 8.0, 8.6 and 13.7 bushels increase respectively.

Improved varieties of other crops, such as Illini, Dunfield, and Richland soybeans and Tama, Vickland, and Marion oats, have increased the yields.

Improved machinery and power have added to better cultural practices and have contributed to performing them on schedule. Records of the Farm Bureau Farm Management Service over an eight-year period in north central Illinois showed an increase of 9.5 bushels for corn and 8.5 bushels for oats due to improved cultural practices used.

Soil fertility has been improved during the last ten years through the planting of increased acreages to legume and grass crops. There has also been a large increase in the use of limestone, phosphate, and mixed fertilizers. A total of only 350,000 tons of limestone was used in Illinois in 1919 compared to about 3,500,000 tons in 1943, a tenfold increase. More than 150,000 tons of phosphate were applied by Illinois farmers in 1943 compared with less than 4,000 tons in 1919 and earlier years. The use of mixed fertilizers has also increased markedly in recent years.

Large United States and world reserves of wheat and large national feed supplies at the beginning of the

TABLE 2.—IMPORTANT LIVESTOCK NUMBERS IN ILLINOIS, 1915, 1918, 1919, 1940, 1943 AND 1944.*

Livestock	1915	1918	1919	1940	1943	1944
Horses and Mules	1,612,000	1,617,000	1,614,000	650,000	515,000	471,000
All Cattle	2,187,000	2,371,000	2,400,000	2,884,000	3,212,000	3,244,000
Milk Cows	1,007,000	1,057,000	1,060,000	1,100,000	1,168,000	1,180,000
Hogs	4,358,000	5,111,000	5,724,000	5,750,000	6,858,000	7,750,000
Sheep	935,000	988,000	1,000,000	883,000	874,000	807,000
Laying Flock			22,081,902	22,953,000	26,832,000	28,128,000
Chickens raised			29,893,565	28,619,000	48,538,000	46,000,000[a]
Eggs produced			105,757,907	161,000,000	223,417,000	232,000,000[a]
Horses, Mules and All Cattle	3,799,000	3,988,000	4,014,000	3,534,000	3,727,000	3,715,000
Hogs and Sheep	5,293,000	6,099,000	6,724,000	6,633,000	7,732,000	8,557,000

* Federal and state crop and livestock reporting service.
a 1944 goals.

present war have added to the emphasis placed on livestock production. All livestock numbers in Illinois except horses, mules and sheep were up at the beginning of the present war and have continued to increase (Table 2). The decrease in horses and mules has been offset fairly well by the increase in all cattle. Numbers of horses and mules decreased 1,151,000 between January 1, 1915, and January 1, 1944, while all cattle increased 1,057,000. The increase in dairy cattle numbers has been moderate during both war periods, however, sheep numbers actually increased during the last war but they have decreased during the present war. Not only were numbers of hogs on Illinois farms nearly a third larger on January 1, 1940, than on January 1, 1915, but they increased another 34.8 per cent between January 1, 1940, and January 1, 1944, compared with a 31.3 per cent increase between January 1, 1915, and January 1, 1919. The poultry industry did not undergo any major changes during the other war period. Numbers in laying flocks and numbers raised were not greatly different on January 1, 1940, from January 1, 1919, but egg production in 1940 was nearly 50 per cent greater than in 1919. The increase of hens in laying flocks from 1940 to 1944 was 22.5 per cent and the increase asked for in egg production for 1944 is 44.1 per cent above that of 1940. A 60 per cent increase is being asked in chickens raised during 1944 over 1940.

Some of the crop and livestock changes of the present war period will become permanent, but more of them are apt to call for readjustment during the postwar period as part of the present markets disappear. A number of recent developments, such as egg drying, milk evaporation, dehydration, use of meat stretchers for export products and more general use of protein concentrates in balancing feeding rations, will contribute to a permanently expanded market for some of the products of agriculture. The longer war and greater depletion of most consumer goods should extend the period of adjustment to normal peacetime demands. A further tool for making satisfactory individual adjustments in the postwar period is the present machinery for establishing yearly production goals.

ANTHROPOLOGY

NEW EVIDENCE FROM THE FISHER SITE

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The Fisher site has occupied an important position in discussions of Midwestern archaeology since Langford's article appeared in 1927 (Langford, 1927). He published further data on the site in two papers in these *Transactions* (Langford, 1928 and 1930). Two more papers resulted from researchs carried out by the University of Chicago (Krogman, 1931 and Eggan, 1932). Despite this published work and the careful notes which Langford graciously placed at the disposal of the Department of Anthropology of the University of Chicago, there remained unsolved problems. With the aim of excavating to solve certain of these problems, a joint expedition of the Illinois State Museum, the University of Chicago, and the W. P. A. spent approximately nine months at the site in 1940 and 1941. The field work was under the direction of Mrs. Gretchen Cutter Sharp. Only a brief note of the results has so far appeared in print (Deuel, 1940). James B. Griffin in his recent summary (Griffin, 1943) was forced to rely on the older data.

The Fisher site is located on the banks of the Des Plaines River, one mile above its confluence with the Kankakee, in Will County, Illinois. It is about thirty feet above the river and about two hundred feet from the old bank. The site is a glacial limestone gravel deposit overlain by a veneer of dark topsoil. On the site about twelve mounds and fifty house pits are found.

Four components have been recognized from the site. The earliest is not too well known, and consists of dolichocranic burials deep in the gravel, mostly unaccompanied by grave goods. Second, the Upper Mississippian component is found. This occupation is responsible for the two large mounds and the house pits, and is the manifestation from which the Fisher focus has been set up. Third, there is a Woodland component associated with the smaller mounds. And, finally, there is an historic component, the tribal identification of which presents several interesting ethno-historical problems. The present paper is concerned solely with the Upper Mississippi component.

Two basic types of Upper Mississippi pottery have been found at the site. One is shell-tempered, the other grit-tempered. Aside from this difference in tempering, however, the two types are very much alike. Both occur in a smooth surface variety and in a quite distinctive cord-wrapped paddle treatment. Similar treatment in the matter of decoration is accorded both. James B. Griffin has recently remarked: "Despite the differences between grit- and shell-tempered types they are remarkably homogeneous in certain respects—

vessel shapes, appendages, rim shapes, surface finishes, and certain decorative ideas and techniques." (Griffin, 1943, p. 279). A problem is raised as to whether these two types represent a sequence, or whether they were contemporaneous in whole or in part. The answer seems to be that they were contemporaneous at least in part; sherds of the two types have been found together in such a position as to indicate this as a practical certainty. Beyond that, however, Deuel (1940, p. 7) feels that perhaps the grit-tempered started earlier, while Langford's data (as used by J. B. Griffin, 1943, p. 279) would seem to indicate the opposite interpretation. Any final decision must await a more complete analysis than has been attempted so far.

One of the major projects of the latest researchs at the Fisher site was the complete excavation of one of the house pits. From this we are in a position to state for the first time, with certainty, the house type of the Upper Mississippi peoples at the site. That the house actually does belong to the Upper Mississippi component seems adequately attested. Only Upper Mississippi sherds were found within the house, in the wall trenchs, and in the postholes.

We have referred several times to the house pits at the site. These must not be confused with such architectural types as the Southwestern pit house or the semi-subterranean lodge of the eastern Plains. As a matter of fact the house pits at Fisher merely represent the clearing away of the topsoil in order to obtain a clean floor. The topsoil and underlying gravel was scraped away to perhaps the depth of a foot or more, and this material was piled around the excavated area, thus forming a ridge around the shallow depression, and giving an apparent depth greater than the actual. This feature is not new; the Middle Mississippian houses of Fulton County have it. In this latter area the topsoil was removed to provide a clean loess floor for the house.

The house which was discovered at the Fisher site was a rectangular structure approximately thirty-five by twenty-five feet in size, with its long axis roughly north-south. This is a relatively large structure for the region. The average Middle Mississippi house in Fulton County is about sixteen feet square. Dwellings up to thirty-five feet in length are reported from the Kincaid site in southern Illinois, but the average at the site is much less than this (Bennett, 1944). The majority of the houses at the Fisher site probably more nearly approximated the standard Middle Mississippian size. The pit in which the house was found was one of the largest at the site; the majority suggest a house between sixteen and twenty feet in size.

The posts which formed the walls of the structure were set in trenches. There were two of these trenches, roughly parallel, one inside the other. The inner trench is consistently shallower than the outer. There seems to be no evidence of open cornered trenches such as are found in some Middle Mississippi houses. On the contrary, on at least two corners of the outer wall, where the evidence is best, there are definite indications that the trench was closed. The posts themselves were set in the trenches, and extended below them for some distance into the gravel. On the average they were .35 of a foot, or roughly four inches, in diameter. In the outer wall the posts average about four to eight inches apart; the inner line shows a consistent tendency to be more widely spaced. The two lines of posts are about two feet

apart. The shallower inner trench and the more widely spaced posts within it unite to emphasize the structural pre-eminence of the outer wall.

Whether the double line of posts indicates a double walled structure, built so for the preservation of heat on the thermos bottle principle, or whether it indicates that a bench entirely encircled the wall on the inside, is a question which cannot be answered at present.

Another feature must be noted. On the east wall of the house, and almost in the middle of that wall, breaks are seen in both the inner and outer lines of posts. Presumably this was the doorway. In front of this doorway, about two feet away and parallel to the walls of the house, is a short shallow trench containing postholes. We may probably interpret this as a wind-break or screen protecting the doorway.

The doorway faces east, towards the Des Plaines river. Also, in relation to the other house pits it faces a roughly rectangular area about four hundred by two hundred and fifty feet in size, about which the house pits are grouped. The house under consideration is on the west side of the area, near the north-west corner. Within the rectangular area were located Langford's two large mounds, from which the cultural stratigraphy of the site was first noted. This arrangement suggests the plaza arrangement which we know from Middle Mississippi sites. The mounds at Fisher, however, are burial mounds and not the familiar Middle Mississippi truncated pyramid.

The wall covering of the house is at present unknown, although ethnobotanical study of some of the charred material found adjacent to and above the wall trenches may provide some clue, when the material is analyzed.

Of the roof structure nothing is known at present. The occasional postholes found within the house do not suggest any interior support, but at the same time a span of thirty-five feet, with the materials available to the Indian, would present structural difficulties of the first order. Both domed roofs, made by bending the green wall poles inward and lashing them in place, and gable roofs have been found at Kincaid (Bennett, 1944). Either of these types are possibilities for the Fisher site.

Both within the house and outside it aboriginal pits were found. The contents of these pits have not been completely analyzed as yet. A firepit was discovered towards the center of the house. This pit begins at about six inches below the present surface of the ground, and indicates once again the essential shallowness of the house pit. The firepit itself disclosed laminations of soil, charcoal, and cultural debris. In the pit was found a considerable quantity of Upper Mississippi sherds, both shell- and grit-tempered types, with the shell-tempered predominating.

Other cultural objects found within the house include small triangular projectile points, deer cannon bone beamers, antler and stone celts, scalloped shell spoons, and bone fish hooks.

Anyone familiar with Middle Mississippian culture will immediately note the great similarity between the house described above and those from Middle Mississippian sites. So far as the author knows, only one other house from an Upper Mississippi site has been described. A rectangular house, about nineteen and a half by seventeen and a half feet,

was found at the Turpin site in Ohio (Griffin, 1943, p. 146). The Turpin site belongs to the Madisonville focus of the Fort Ancient aspect. Thus, both instances of Upper Mississippi houses indicate a rectangular floor plan, very similar to that of Middle Mississippi dwellings.

It is not surprising that the house type of this Upper Mississippi site should be so like that of Middle Mississippi sites. Although several hypotheses have been suggested to explain the origin of Upper Mississippi, all of them have recognized the strong Middle influences on Upper.

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MIDDLE WOODLAND CULTURES

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The term Middle Woodland, as used here, represents a stage of development of Woodland culture as well as a time period in Illinois prehistory. This period is delimited by the earlier Hopewell peoples and the later Mississippian group. As a stage of development within the Middle Woodland pattern it manifests certain characteristic traits that relate it to both early and later Woodland groups and other traits that represent this particular stage. As the sites indicating this stage are not numerous and as the development of culture is continuous, I qualify the above mentioned hypothesis by stating that some of the sites chosen as representing the Middle Woodland stage may have extended after the Middle Woodland time period.

This stage of development is represented at a number of sites throughout the southern two-thirds of the state of Illinois (and possibly at sites in Green County, Indiana, and at sites along the Missouri River in Missouri). These sites make up the components of the following foci: the Lewis focus of Pope and Massac counties[1], the Raymond focus of Johnson County[2], the Parker Heights focus of Adams County[3], the Maple Mills focus of Fulton County[4], and the Pere Marquette[5], and Isringhausen foci[6] of Jersey County. In all but the first two of these foci, there is no stratigraphy indicated and their chronological position must be established on the basis of trait complexes.

The traits that are common to most of these foci and are characteristic of the Middle Woodland stage of development are presented in the tabulated summary. Occurence of these traits are indicated by an x.

It has been postulated that peoples having a common complex of traits are culturally related. To this I add a second postulate that people having a common complex of traits are temporally related. Having defined my terms and stated the postulates basic to this study, I shall now attempt to solve the major problem. Specifically, the problem is to show that the foci mentioned previously did exist during certain parts of the time period between the Hopewell and Mississippi occupations, and moreover, to place the Middle Woodland cultures in their correct sequential position in the various regions where they occur.

The method employs the use of stratigraphic evidence and the comparative analysis of traits. Since

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TABLE SHOWING RELATION OF MIDDLE WOODLAND TO OTHER HORIZONS IN ILLINOIS

ARCHAEOLOGICAL HORIZONS IN ILLINOIS	Fulton County	Adams County	Jersey County		Southern Ill.	
			Bluffs in Northwestern Jersey Co.	Pere Marquette State Park	Carbondale Region	Pope and Massac Counties
HISTORIC LATE WOODLAND and MISSISSIPPI PERIODS	Upper and Middle Mississippi Maple	Mississippi materials	Middle Mississippi	Upper Mississippi Pere	Middle Mississippi and Dillinger	Middle Mississippi
MIDDLE WOODLAND PERIOD	Mills	Parker Heights	Bluffs sites	Marquette Sites	Raymond	Lewis II Lewis I
HOPEWELL PERIOD	Hopewell	Hopewell	Surface sherds of Hopewell		Intrusive Hopewell Materials	
EARLY WOODLAND PERIOD	Red Ochre				Crab Orchard	Baumer
PRE-POTTERY PERIOD						Faulkner

	Lewis	Raymond	Maple Mills	Pere Marquette	Parker Heights	Isring-hausen
I. Burial Customs						
a) Burials under stone slabs	x	x	.....	.....	x	x
b) Multiple burials	x	.....	x	.....	x	x
c) Burials in pits	x	.....	x	x	x	.....
d) Grave goods lacking or rare	x	.....	x	x	x	.....
II. Industries and Art Forms						
a) Knives, triangular in shape	x	x	x	x	x	x
b) Projectile points, type I						
side-notched	x	x	x	x	x	x
straight-stemmed	x	x	x	x	.....	x
c) Projectile points, type III						
side-notched	x	x	x	.....	x	.....
III. Pottery Complex						
a) Temper-grit	x	x	x	x	x	x
b) Surface finish,						
predominently cord-marked	x	x	x	x	x	x
c) Decoration,						
notching on the lip	x	x	x	x	x	x
incising on the rim	x	.....	x	x	x	x
d) Shape,						
subconodial base	x	x	x	x	x	x
lack of well defined						
shoulder	x	x	x	x	x	x
vertical rims	x	.....	x	x	x	x
IV. General Traits						
a) Sites on bluffs	x	x	x	x	x	x
b) Hunting economy	x	x	x	x	x	x
c) Small sites	x	x	x	x	x	x

stratigraphy is a more reliable type of data, I shall start with the examination of an area having it and then examine regions where sequences must be established on the basis of traits.

In Pope and Massac counties the sequence of cultures has been established by the University of Chicago at the Kincaid and adjacent sites. The sequence is Baumer, Lewis, and the Middle Mississippi foci. The Lewis focus, having the diagnostic traits of the Middle Woodland stage of development, is thought to be of that time period. This sequence of culture can be checked with the sequences of cultures found in the Carbondale area, which is: Crab Orchard, a small period of Hopewell intrusion, the Raymond focus, and the Dillinger focus. A comparison of the Raymond and Lewis traits shows these two foci to be culturally affiliated and contemporary. Since the Raymond focus is superimposed on Hopewell remains and the Lewis materials are below a Middle Mississippi component, it may be surmised that both the Raymond and the Lewis foci are of the Middle Woodland period. The inclusion in Lewis of such Middle Mississippi traits as plates, square houses, olla shaped vessels, slipped and painted pottery vessels tends to place it a little later in the Middle Woodland period than the Raymond focus.

The next region under consideration is that of southwestern Jersey

County, specifically the sites at Pere Marquette state park. Here stratigraphy is indicated at the adjacent sites, 710a and 710b. At 710a Upper Mississippi sherds are found in large amounts at the surface and decrease in amount at each underlying six-inch layer. At 710b there are no Upper Mississippi sherds. Thus it seems likely that 710b represents a late stage of the Middle Woodland period whereas 710a seems to have been occupied in the later Mississippi period.

In northwestern Jersey County, the Isringhausen site is of the Middle Woodland stage of development. No stratigraphy exists at this site. However, the occurrence of cremations, stone slab burial mounds, burial pavements, oblong flint knives, pottery grave goods, and plummet stones—Hopewell traits—place this manifestation early in our Middle Woodland period. Contemporaneity tends to be negated by the absence of any trade pottery from Hopewell groups who occupied the adjacent area.

The Parker Height focus of Adams County is also lacking in stratigraphy. Stone slab burial mounds, cremations, and fireplaces in the burial mounds — Hopewell traits — and the inclusion of the Mississippi of shell temper and elbow pipes place it in the middle part of the Middle Woodland period. The Spencer component of this focus may be later in time as it has expanded base drills, a Mississippi trait.

The components of the Maple Mills focus seem in the main to be later than the Middle Woodland Period. However, the fact that at the Clear Lake site the majority of the pottery of the Maple Mills focus was found under the twelve Mississippi sherds plus the fact that identical cord-marked pottery vessels are found in both the underlying Hopewell materials and the Maple Mills materials[7] indicate that it is of the Middle Woodland period. That it extended into the Mississippian period is indicated by the Mississippi traits such as triangular projectile points, raised points on the lips, and shell spoons.[8]

On the basis of the above mentioned evidence it seems plausible that the sequences of cultures presented in the accompanying table illustrates the chronological position of the various Middle Woodland foci. In conclusion a general statement may be made concerning part of the history of the Woodland groups: that they were a group of related Woodland peoples having a common trait complex who had developed from an early Woodland base and who occupied portions of Illinois between the Hopewell and the Mississippi occupations.

[7] E. Schoenbeck persona. communication.

[8] O. Wray, University of Chicago, informs me that he has excavated Maples Mills burials under a Middle Mississippi village.

MORE DATA ON CLEAR LAKE VILLAGE

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Peoria, Illinois

This paper is a further report on Clear Lake Village[1] cultural objects obtained through continued excavations by G. and E. Schoenbeck and A. Simpson, members of the Peoria Academy of Science. It contains more data on pottery, identifications of animal remains from the Schoenbeck collection (other than the Mollusca reported in 1943), and a list of added items new for the site.

Of particular significance is the pottery collected. It now includes all types reported by Fay-Cooper Cole and Thorne Deuel in "Rediscovering Illinois", concerned with Fulton County sites primarily; representations of most pottery described by James B. Griffin and Richard G. Morgan in "Contributions to the Archaeology of the Illinois River Valley"[2] for the Hopewellian and the Maples Mills sites of the lower Illinois River area; and other. It comprises Early Woodland, Early Woodland-Hopewellian, Hopewellian in many variations of both local and imported, Maples Mills in several variations, Mississippian of several types, various unidentified specimens and other.

The richness and inclusiveness of the pottery complex and the significance of its features now ranks Clear Lake as outstanding among Illinois sites reported to-date. It has produced materials stated by James B. Griffin of the Ceramic Repository for the Eastern United States, Museum of Anthropology, University of Michigan, to be rare in Illinois and quite important, and is the only site known to him in the north which has the Marksville red-filmed ware from Louisiana.

Additions of interest include the Marksville red-filmed ware (reported in 1940 by the writer as Cole and Deuel's type No. 4); negative painted rims from the Lower Mississippi Valley, including the thickened rim and other; sherds comparable to Adena plain and to Marksville plain; a heavy, extremely coarse tempered flat-lipped ware, cord-roughened on both exterior and interior, identified as "Red Ochre Ware like Adena type, 'Fayette Thick' ", possibly the same as Cole and Deuel's type No. 6, the description of which lacked mention of rim and exterior surface finish. Other identifications include an Early Woodland Hopewellian with interior boss and an Early Woodland with cord-roughened interior and smooth exterior.

Newer decoration identifications comprise chisel stamp, bar stamp, depressed band, Morton incising, herringbone incising, ridge pinched, scoring, gashed incising, and Gono cord.

Identifications of surfaces added are brushed, white slip on Hopewell, Baumer fabric impressed, plain plaited, and cord-wrapped dowel. Mississippi ware, in addition to that previously reported, has been identified as Spoon River; Spoon River red slip, bean pot; Spoon River with

[1] Clear Lake Village, located in Tazewell and Mason counties, and originally reported by Drs. Fay-Cooper Cole and Thorne Deuel in "Rediscovering Illinois", University of Chicago publication, 1937. Reported by E. Schoenbeck in 1940, 1941, 1942, 1943, Transactions of Illinois State Academy of Science.

[2] Transactions of the American Philosophical Society, 1941. University of Illinois explorations under direction of Dr. Warren K. Moorehead.

Oneota decoration; "Early Middle Mississippi style associated with Old Village at Cahokia, depressed background"; "Old Village, similar to Powell plain". Various rims could not be identified. All identifications given here were made by Dr. Griffin.

Of interest were a Woodland smoothed-over cord-roughened rim showing a patch extending over rim on to both inner and outer surfaces, and a Black Sands incised rim with decoration continued on to the subsurface where an area of the surface had apparently slipped off during the decorating. One plain rim has a little upthrust ear on lip. Decoration on the Black Sand incised extends on to body; a diamond pattern is included in the designs. Walls with double curve occur in the Havana zoned stamped. Hopewell rim incised includes the cross-hatched, the horizontal, and the rocked incising. A highly polished Hopewellian rim with herringbone incising converging at the crest of the inner and outer surfaces of a beveled lip, is stated by Dr. Griffin to be one of the best he has ever seen.

Occurrences which can be reported for the Gooden cord impressed, or cord decorated, or Maples Mills corded-design ware are designs of double rows of alternating plain and hatchured triangles; of diamond pattern (found also at Bloomenshine and Mossville sites); designs of horizontal "lines" as chief rim decoration; and ungeometrical, though angular, designs. "Cord punctate" is a designation offered by the writer as correct for the punctate on this ware[3]. This cord punctate appears with the cord lines on much of the ware. Two types of cord roughening, one quite distinct in appearance and quite frequent, occur. A plain smooth vertical rim, with the black angular tempering so much used in this ware, bears a cord imprint in the lip, running around the entire circumference. Shapes added to the flattened globular olla with vertical neck and the globular olla with vertical neck are a sloping necked jar with cord decoration, poorly executed, and a collared, angular shouldered olla without cord-decoration.

Several miniature vessels are represented among the rims at the site. There is a good representation of fine Hopewell, both local and imported. Variations in shape and decoration are numerous. Bossing is used considerably. It is frequent on the more elaborately decorated of the dentate-stamped and on the heavier cord-wrapped-stick decorated. It is rare on the rims whose major decoration is punctating. It is present on plain ware and on incised rims, including the Black Sand incised. It never occurs on the lighter weight of the cord-wrapped-stick decorated rims, nor on the light weight lip-punctated ware.

Shapes include, among the Woodland and Hopewellian, the wide-mouthed, sloping-shouldered jar; the straight-sided pot; the flaring-mouthed or flowerpot shape; the round-bodied pot with vertical neck; the round-bodied with sloping neck; the incurved rim; the double-curved wall; the low bowl with straight side; the low bowl with incurved rim; the low bowl with thickened rim, and others. Among the Mississippian items are a water bottle with vertical neck; an olla with short, abrupt, flaring rim; and a short vertical rim. A two and one half inch wide sherd with two finished edges and bearing

[3] The description of Cole and Deuel's type 5, Maples Mills Corded-Design, in "Rediscovering Illinois" mentions no punctate; a punch mark (without descriptive term) is mentioned in description of Gooden site pottery.

Photograph by William Holling

Pots 1, 3, and 5 (top row) are decorated with cord-wrapped-stick and have cord-roughened bodies.
Pot 2 (top row) has horizontal herringbone decoration on rim, with plain band above.
Pot 4 (top row) is plain and is perforated.
Pot 6 and 7 (bottom row) are plain.
Pot 8 (bottom row) is cord-roughened surface, undecorated.
Pot 9 (bottom row) is a minature, with circle imprint decoration.
Pot 10 (bottom row) is plain surface, with boss.
Pot 11 (bottom row) is the red-painted, thickened-rim.

gashed decoration, has been identified as an extraordinarily wide strap handle, in this ware.

Rims, lower rims, and decorated body sherds now total over 3000 in the Schoenbeck collection. Rims collected by Mr. A. Simpson, included in earlier reports, number several hundred. Around 75 pot portions sufficient for projection have been collected. Eleven projected vessels from the Schoenbeck material are shown in the illustration; seven were projected by the Illinois State Museum, the others, by Mr. Simpson.

Other cultural objects to be reported here are a third copper pin; another snailshell cache; a C-shaped copper bracelet; a calcaneus bone with perforation; a portion of turtle carapace with perforation; a portion of branched antler with perforation. A 7-inch, curved, antler "chipper" is another item. Two stone objects are a portion of a flat oblong stone with wide, shallow, flat, central groove, perhaps a part of a shaft-straightener, and a celt-shaped object with one lengthwise edge unthinned, flat and smooth.

It must be reported that the site was largely destroyed in 1943 by still further extensive excavation of material for road and dike rebuilding.

Only a small portion of the large number of bones were submitted for identification. Of mammals, seventeen species, including human bones, are represented. Of interest is the beaver, now extinct in Illinois, and the otter, stated to be practically absent from the state excepting in the southern part where it is rare. Deer bones were the most abundant, being exceedingly numerous. Of significance, perhaps, is the fact that practically all bones with the exception of the very small ones and of the human ones, were broken. Bison remains included a skull, previously reported.

In the fish, twelve species and families were identified by Dr. Reid and three were added by Dr. Hansen, through identification of fish scales. Of interest are the otoliths of the drumfish, or sheepshead, also frequent on other sites. They are all sacculiths, one of three pairs of bones in the auditory capsule of fishes, the other pairs, the utriculiths and the lagenaliths, not being represented. Dr. Reid could offer no reason for this difference in representation other than size, perhaps, the others being smaller.

Thirteen species of bird bones were named for the site. The chicken bone identified among them was suggested by Dr. Friedmann as being probably a whiteman's intrusion into what might well be an old site.

The Reptilia is represented by turtle remains, only. These are very numerous at the site.

A comparison with the animal remains from the Kingston Lake Village, a Mississippian site not far distant, considered more recent, shows mammals, including humans, Clear Lake 17, Kingston Lake 14; Birds, Clear Lake 12 (minus the chicken), Kingston Lake 31; Fishes, Clear Lake 15, Kingston Lake 6; Reptilia, Clear Lake 4, Kingston Lake 2; Mollusca, Clear Lake 37 (24 mullusks, 13 gastropods), Kingston Lake 23 (21 mussels, 2 snails). The Kingston Lake total of 21 species of mussels, published in 1936[4], was stated by Frank Collins Baker, University of Illinois, to be the largest number of species of mussels reported from any kitchen midden deposit yet recorded. The Kingston Lake total representation would be raised to 22 with inclusion of the conch shell, used for several tools. It is of interest that Clear Lake exceeds this, having a total of 24. The difference in bird remains, Clear Lake 12 (minus the intrusive white man's chicken bone) and Kingston Lake 31, could have significance. It might suggest that the Clear Lake people depended in much lesser degree upon birds as an article of food. The excess in Mollusca at Clear Lake over Kingston Lake, 37 to 24, is noted.

Identification of animal remains given in this report include those of mammals, birds, reptiles and fishes. The material was identified by scientists in the United States National Museum and in the Illinois State Natural History Survey, and the thanks of the writer are due these specialists for their exceedingly painstaking work in identifying even the most fragmentary material. The naming of the groups should be credited to the following persons:

Mammals. Dr. David H. Johnson, United States National Museum.

Birds. Dr. Herbert Friedmann, Curator of Birds, Smithsonian Institution.

Reptiles. Dr. Doris M. Cochran, Associate Curator of Reptiles, Smithsonian Institution.

[4] Transactions of the Illinois State Academy of Science, 1936.

Fishes. Mr. Earl D. Reid, Senior Scientific Aid, Division of Fishes, Smithsonian Institution, and Dr. Donald F. Hansen, Assistant Zoologist, Illinois State Natural History Survey Division.

List of Species Represented

MAMMILIA (MAMMALS)

Deer, *Odocoileus* (probably white-tailed deer, *O. virginianus*): 49. Antler fragment, 7; ear bone 5; vertebrae, 5; skull fragment, 4; atlas, 4; astragalus, 4; calcaneum, 4; mandible, 3; axis, 3; distal phalanx, 2; medial phalanx, 2; tooth, 2; scapula, 1; innominate, 1; radius, 1; rib, 1.

Elk, *Cervus canadensis*: 16.
Tooth, 5; metatarsus, 3; calcaneum, 2; scapula, 1; innominate, 1; humerus, 1; skull fragment, 1; atlas, 1; vertebrae, 1.

Bison, *Bison*: 18.
Proximal phalanx, 3; tibia, 3; humerus, 2; ulna, 2; scapula, 2; astragalus, 2; medial phalanx, 1; patella, 1; rib, 1; radius, 1.

Dog, *Canis familiaris* (Some of the bones might be coyote, *Canis latrans*): 31. Mandible, 10; rib, 4; phalanx, 3; vertebrae, 3; femur, 2; tibia, 2; skull fragments, 2; calcaneum, 1; astragalus, 1; innominate, 1; atlas, 1; radius, 1.

Raccoon, *Procyon lotor*: 46.
Loose teeth, 21; mandible, 10; skull fragment, 8; penis bone, 2; humerus, 2; ulna, 2; radius, 1.

Badger, *Taxidea taxus*: 3.
Mandible, 2; skull, 1.

Mink, *Mustela vison*: 11.
Mandible, 8; femur, 1; ulna, 1; innominate, 1.

Black bear, *Euarctos americanus*: 2.
Upper canine, 1; calcaneum, 1.

Otter, *Lutra canadensis*: 3.
Humerus, 1; ulna, 1; tibia, 1.

Wolf, *Canis lupus*: 1.
Mandible, 1.

Bobcat, *Lynx rufus*: 2.
Humerus, 1; femur, 1.

Muskrat, *Ondatra zibethica*: 27.
Mandible, 10; femur, 5; tibia, 4; innominate, 3; skull fragment, 2; humerus, 2; atlas, 1.

Beaver, *Castor canadensis*: 12.
Vertebrae, 5; femur, 1; mandible, 1; lower incisor, 1; upper incisor, 1; tibia, 1; sacrum, 1; humerus, 1.

Pocket gopher, *Geomys breviceps*: 9.
Mandible, 4; skull, 2; upper incisor, 2; humerus, 1.

Fox squirrel, *Sciurus niger*: 1.
Skull, 1.

Cottontail, *Sylvilagus*: 1.
Tibia, 1.

Human: 6.
Proximal phalanx, 2; femur, 1; rib, 1; sacral vertebrae, 1; metatarsal, 1.

AVES (BIRDS)

Blue-winged Teal, *Querquedula discors*
Humerus, 1.

American Widgeon, *Mareca americana*
Ulna, 1.

Pintail, *Dafila acuta*
Humerus, 1.

Black Duck, *Anas rubripes*
Ulna, 1.

Wood Duck, *Aix sponsa*
Ulna, 1.

Pied-billed grebe, *Podilymbus podiceps*
Tibiotarsus, 1.

Large Hawk, unident
Claw, 1.

Wild Turkey, *Meleagris gallopavo*, 5

Canada Goose, *Branta canadensis*, 6

Shoveler Duck, *Spatula clypeata*, 1

Black Duck, *Anas rubripes*, 2

Crow, *Corvus brachyrhynchos*, 1

Baldheaded Eagle, *Haliaeetus leucocephalus*, 1

Chicken, *Gallus domesticus*, 1

REPTILIA (TURTLES)

1 complete carapace of *Terrapene*, also small shell and bone

Fragments of shells of *Pseudemys*

Fragments of shells of *Amyda*

Fragments of bones of *Chelydra*

PISCES (FISH)

Bowfin, *Amia calva*
Left opercle, 5; right opercle, 12; gular plate, 5; left postorbital, 1; right shoulder girdle, 1; left shoulder girdle, 1; lower left postorbital, 1; left posterior branchiostegal ray, 1; left branchiostegal ray, 4; left subopercle, 1; right posterior branchiostegal ray, 1; left dentary (posterior fragment) 1; head bone, 1; vertebrae, 2; splenial, a thin bone lying on inner surface (articular) 1;

maxillary, 1; dentary, 6; parasphenoid, 1.

Catfish, *Ameiurus sp.*
Right articular and mandible, 1; dentary, 1; scapular, 3 and fragments 3; Modified vertebrae and associated bones of the Weberian apparatus, 1; Modified anterior vertebrae and associated bones of the Weberian apparatus, 2; abdominal vertebrae; Quadrate, Metapterygoid, Entopterygoid, Symplectic (right side of head) fragment of shoulder girdle, 2; right pectoral spine, 1; left pectoral spine, 1; scapular arch, fragments, 4; right articular (fragment); dorsal spine, 1.

Drumfish, *Aplodinotus grunniens*
First interhaemal spine, 2; left half of the lower pharyngeal, 1; upper right half of the pharyngeal, 1; second anal spine, 3; dorsal spine, 1; maxillary, 1; pharyngeal teeth; otoliths,

Buffalo-fish, *Ictiobus sp.*
Right opercle, 1; opercle (fragment), 1; maxillary, 1; vertebrae.

Black bass, *Micropterus sp.*
Right articular, 1; lower part of scapular arch (fragment); upper part of scapular arch (fragment); right interopercle, 2; dentary; interopercle (fragment); posterotemporal; Epihyal; ceratohyal.

Gar, *Lepisostus sp.*
Dentary (fragment of lower jaw); palatine (fragment) 2; left dentary (fragment); right dentary (fragment); parasphenoid, 2.

Sucker, *Moxostoma sp.*
Right pharyngeal bone and teeth; hypural; pharyngeal and teeth; shoulder girdle, 2.

Pike, Pickerel, *Esox sp.*
Dentary, 2.

Carp, *Carpiodes cyprinus*
Right maxillary.

Carp-sucker, *Carpiodes carpio*
Maxillary; subopercle; preopercle.

Carp-sucker, *Carpiodes sp.*
Post clavicle; maxillary (fragment); various ribs; posterotemporal.

Teleost
Vertebrae, 4; fragments, 4; subopercle; opercle (fragment); Hypural; dorsal spine, 3; interhaemal spine; brancheostegal ray, 2.

Centrarchid
Preopercle (fragment)

Identification of Fish Scales
By D. F. Hansen

Dogfish, *Amia calva*

Sunfish, *Centrarchidae*

Gar, *Lepisostens*

Crappie, *Pomoris*

Sheepshead, *Aplodinotus grunniens*

Buffalo, *Ictiobus*

Quillback, *Carpiodes*

BOTANY

EASTERN WHITE PINE AS A TIMBER TREE IN ILLINOIS

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The lumber industry in the United States was founded on eastern white pine, *Pinus strobus L.* White pine lumber from the Lake States played a leading role in the rapid development of the Middle West. The treeless prairies of Illinois took tremendous quantities of white pine lumber for their development.

From a period extending from shortly after the Civil War to approximately the beginning of the twentieth century the Lake States produced more lumber than any other region in the United States. This production was made possible by its extensive stands of virgin white pine. Many of these stands contained trees 200 to 300 years old, 150 to 200 feet high, and 4 to 7 feet in diameter. Today the Lake States produce about 3 per cent of the country's lumber production.

King white pine was the name given to this tree by a group of New York foresters to emphasize the inherent qualities of this species and to put it, so to speak, in a class by itself. It has been called the wood of a thousand uses. White pine has been put to a greater variety of uses than any other species. It has a uniform texture, possesses a straight grain, kiln dries well, shrinks little, and is easy to work with tools. It can be glued readily and does not split easily when nailed. The wood is light in weight, moderately soft, and holds paint well. Although moderately weak, this is not a limiting factor in its many uses. White pine lumber is ideally suited to the construction of almost any part of a house. Handsome houses built of white pine in New England some 200 years ago are still in excellent condition. In the past when the supply was abundant, its principal use was construction. The second-growth ma terial now found on the markets comprises the lower grades and is used largely in box construction. The more exacting demands of the pattern and casting industry utilize the best grades. Knotty pine is used extensively for interior trim. Other uses are for sash, doors, toys, finish trim, flooring, car construction, woodenware, caskets and signs.

Eastern white pine is native to northern Illinois. The southern limit of its range in this area was represented by a two-acre stand on the west bank of the Spoon River in Knox County. These trees have been cut. A few scattered trees occur on the banks of the Illinois River in LaSalle County, in the Apple River Canyon in Joe Daviess County and on the banks of the Mississippi River in northwestern Illinois. The largest single natural stand comprises the

TABLE 1.—EASTERN WHITE PINE

Plot No.	Age from seed	Trees per acre	Av. Ht. dom. & codom. trees	Site index	Av. D. B. H.			Basal area*	Volume per acre		Mean annual growth		
					Dom. & codom.	All trees	Range		Trees 2″ and over	Trees 8″ and over	Ht. dom. codom. trees	d. b. h. dom. & codom. trees	Volume
	Years	No.	Feet	Feet	Inches	Inches	Inches	Sq. Ft.	Cu. Ft.	Bd. Ft.	Feet	Inches	Cu. Ft.
113	32	552	47	77	8.6	7.6	5–14	176	3,933	15,392	1.47	0.27	123
115	31	700	44	77	8.0	7.0	3–12	188	4,008	12,300	1.42	0.26	129
114	32	732	44	73	7.4	6.3	3–11	172	3,773	10,388	1.37	0.23	118
116	36	592	47	68	8.6	7.6	3–15	184	4,115	16,788	1.30	0.24	114
104	58	236	60	52	12.2	11.4	7–15	167	4,498	27,834	1.03	0.21	64
76	82	52	67	45	20.5	18.6	10–26	98	2,683	18,568	0.82	0.25	33
C3	72	196	61	44	12.4	11.3	7–18	137	3,716	22,849	0.85	0.17	52
60	81	113	59	40	17.8	16.4	11–24	165	4,220	27,124	0.73	0.22	52

Plot No.	County	No. of trees measured	Orig. spacing (ft.)	Soil number and type	Gen. agr. crop rating	Adaptability to site	Remarks
113	Ogle	138	.....	53 Plainfield fine sand	9	Very good	Thrifty, well developed, artifically pruned
115	Ogle	175	.....	53 Plainfield fine sand	"	Very good	Thrifty, well developed, artifically pruned
114	Ogle	183	.....	53 Plainfield fine sand	"	Very good	Thrifty, well developed, artifically pruned
116	Ogle	148	.....	53 Plainfield fine sand	"	Good	Thrifth, well developed, artifically pruned
104	Grundy	118	.....	88 Hagener fine sand	"	Fair	Some trees cut
76	Lee	87	.....	41 Muscatine silt loam	2	Poor	Remnants of an overmature plantation
C3	Champaign	204	4 x 4	152 Drummer clay loam	1	Poor	Badly wind-thrown, flat-topped, poorly developed
60	Lee	71	.....	52 Caledonia silt loam	2–5	Poor	Flat-topped

* Basal area is the total cross sectional area in square feet of all trees at 4½ feet from the ground.

White Pine Forest State Park in Ogle County. These trees are approximately 100 years old, 100 feet high and the larger ones are close to 30 inches in diameter.

Eastern white pine is the most valuable conifer that can be grown for forest products in Illinois. It has lost some of its favor as a reforestation species in New England and Lake States because of its susceptibility to white-pine blister rust *Cronartium ribicola* Fischer, and white-pine weevil *Pissodes strobi* Peck. White-pine blister rust has not been found on white pine in Illinois. The intermediate stage of the rust has been found[1] on currants and gooseberries. Local eradication of these bushes from the protective zone of the pine stand will insure protection from the disease. The presence of the white-pine weevil in Illinois was reported for the first time September 1943 by Ernest D. Bergeson*, state leader of white-pine blister-rust control in Illinois. The specimen was identified by Dr. MacAloney, forest entomologist for Region 9 of the United States Forest Service.

If white-pine forests are to be made an important source of timber in this state through planting, it is essential to have the facts regarding the commercial possibilities of this tree. Table 1 presents a detailed tabular statement on the growth and yield of white pine in central and northern Illinois. The growth data for white pine indicate very definitely that it cannot be grown profitably on the heavier prairie soils i.e., clay and silt loams. The high land values of good prairie soils and the rapid decline in growth-rate of this species after 20 or 30 years are the limiting factors. With some 3,000,000 acres of land in Illinois of questionable agricultural value and suited primarily for the growing of forest trees, there seems little justification to plant trees on the better prairie soils, except for windbreaks and farm woodlots of a highly specialized nature and subject to very intensive management. The young white pine plantations now growing on dune sands (No. 53 Plainfield fine sand and No. 54 Plainfield sand) in Mason, Henderson, and Bureau counties show excellent vigor and are growing rapidly. If this growth-rate is maintained in the older ages on these sites, it will be apparent that many acres of land too poor for agriculture can be planted to white pine as a valuable forest crop. Future development of young red, white, and jack pine plantations now growing on these dry sand areas may, however, prove that red and jack are better suited to these sites.

The growth data for plots Nos. 113, 114, 115 and 116 as found in Table 1 offer real encouragement for planting white pine in northern Illinois. These plots are growing on Plainfield fine sand and are located on the hilly area in the Sinnissippi Forest lying along Rock River in Ogle County. Heretofore, these dry ridges supported a very low-quality black oak, *Quercus velutina* Lamarck, producing less than 25 cords of fuelwood per acre at 60 years. None of these trees were of saw-log quality. Previously these areas had been grazed with degrading consequences. The site quality for the pine on the ridges is slightly better than 2 while the lower slopes are site quality of 1 or not quite so good.

Lumber yields of eastern white pine as given by Frothingham[2] are shown in Table 2.

The yield of 60,200 board feet per acre for site I at age 60 is equivalent to over 1,000 board feet per acre per

* By correspondence of September 1943.

Basal area is the total cross sectional area in square feet of all trees at 4½ feet from the ground.

TABLE 2.—YIELD PER ACRE IN LUMBER OF EVEN-AGED SECOND-GROWTH WHITE-PINE STANDS

Age	Lumber Yield Per Acre		
	Site Quality I	Site Quality II	Site Quality III
Years	Board Feet	Board Feet	Board Feet
20	4,500	.....	.....
25	8,400	5,400	.....
30	13,900	9,600	5,300
35	22,500	15,900	9,300
40	32,800	23,500	14,200
45	41,800	30,600	19,200
50	49,100	36,600	24,100
55	55,000	42,000	29,000
60	60,200	46,900	33,600
65	65,100	51,600	38,100
70	69,900	56,100	42,300

TABLE 3.—ESTIMATED COST OF GROWING EASTERN WHITE PINE IN NORTHERN ILLINOIS Planted in Ogle County, 1905

Items of Cost	Time of occurrence Years after planting	Compounded For years	Cost Per Acre	
			Cash invested	Accumulated to 60th year at 3%
Planting				
Stock, 1200 trees at $12 per M	0	60	$14.40	$84.84
Transportation	0	60	2.00	11.78
Labor at 30 cents per hr. plus supervision	0	60	10.00	58.91
Pruning 200 trees per acre; 1st	15	45	2.40	17.55
2nd	18	42	2.00	11.49
3rd	21	39	3.60	18.84
Protection				
Fire, Annual charge 5 cents	.....	.....	3.00	8.15
White pine blister rust, Initial eradication $2.00	.....	.....	2.00	11.78
White pine, Annual charge 6 cents	.....	.....	3.60	9.78
Administration, Annual charge 50 cents	.....	.....	30.00	81.53
Interest on land investment[1]	0	60	47.70[2]	233.33
Taxes $ .15 in 1905 to $ .26 in 1942 (Remaining est.)	Annually	0-60	16.23	41.06
			$136.93	589.04

[1] Land cost $47.70 per acre in 1905.
[2] Owner still possesses land after forest is removed.

TABLE 4.—ESTIMATED RETURNS FROM GROWING EASTERN WHITE PINE IN NORTHERN ILLINOIS

Planted in Ogle County, 1905

Operation	Product and Quantity Obtained	Time of occurrence Years after planting	Interest compounded for yrs.	Returns per acre	
				Original	Accumulated to 60th yr. at 3%
1st thinning..	391 posts at 10 cents per post.....	34	26	$ 39.10	$ 84.32
	1634 bd. ft. at $8.00 per M.....	34	26	13.07	28.19
2nd thinning..	270 posts at 10 cents per post.....	40	20	27.00	48.76
	1437 bd. ft. at $10.00 per M.....	40	20	14.37	25.95
3rd thinning..	142 posts at 10 cents per post.....	45	15	14.20	22.10
	5813 bd. ft. at $12.50 per M.....	45	15	72.66	113.20
4th thinning..	16 posts at 10 cents per post.....	50	10	1.60	2.15
	6160 bd. ft. at $15.00 per M.....	50	10	92.40	124.18
5th thinning..	4750 bd. ft. at $18.00 per M.....	55	5	85.50	99.12
Final cut.....	52,769 bd. ft. at $20.00 per M.....	60	0	1055.38	1055.38
				$1415.28	$1,603.35

Gross receipts	$1,603.35
Total Cost	589.04
Net Profit	$1,014.31

$16.91 per acre per year net profit

year. Intermediate cuttings in the form of thinnings should add another 20,000 board feet giving a gross yield of 80,000 feet. This goal can be achieved only with the application of intensive forest management. In addition to the lumber yield approximately 800 seven-foot fence posts will be obtained from the trees 4 through 9 inches in diameter.

Plots 113 through 116 in Ogle County were thinned at age 34. Better development would have resulted from thinnings made 10 to 15 years earlier. All crop trees were pruned through the first 16-foot log. That a financial rotation from 60 to 70 years is suitable is suggested by the growth of old white pine on a somewhat similar site on the White Pine State Forest which lies 8 miles west of the Sinnissippi Forest.

Table 3 shows the estimated costs of growing white pine in Ogle County under conditions as outlined in the table. This land actually cost $47.70 per acre in 1905. Tax statements for these lands during the

period from 1905 through 1942 were secured from the Ogle County Court House. The yield data secured in the first thinning at age 34 are actual. Subsequent yield data from thinnings and the final cut were carefully estimated from yield and stand tables for a comparable site. All cost data were carried from time of occurrence to the end of the 60 year rotation at 3 per cent compound interest. The largest single item of cost was $233.33 which represents the interest on the land investment of $47.70 for 60 years.

Table 4 gives the estimated returns from growing white pine on this same area. All cash returns were carried from time of occurrence to the end of the rotation at 3 per cent compound interest. The net profits at the end of 60 years were $1,014.13 per acre. This is equivalent to a net profit of $16.91 per acre per year. Sinnissippi Forest possesses its own sawmill. It has a ready market in nearby Oregon and Rockford for treated fence posts, fuelwood and all types of lumber sawed to specification. Additional revenue can be expected as a profit on logging, sawmilling and marketing of products manufactured by forest labor.

The remaining pine plots in Table 1 are typical forest plantations found on Illinois farms. For the most part they are overgrazed, either understocked or overstocked, and have had no care since they were set out. Under their present conditions they offer little chance of supplying badly needed lumber for the farm. From an investment standpoint they must be considered a failure.

Extensive areas of light sandy soils along Rock River in Ogle County are, at the most, now returning only small amounts of fuelwood and meager grazing of low forage value. The possibility of securing a net profit from growing white pine at $16.91 per acre per year, in addition to 3 per cent on invested capital, affords an excellent opportunity for these areas.

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NOTES ON SOME PLANTS THAT ARE RARE IN ILLINOIS

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These notes are offered in the hope they may stimulate research and may result in the extension of the ranges of these species. As yet the flora of Illinois is very imperfectly known and with the growth of cities and towns many of the original habitats have vanished or are disappearing. The known occurrence of the following species is evidenced by specimens in the herbaria of the University of Illinois at Urbana, The State Museum at Springfield, or the Chicago Natural History Museum (Field Museum) at Chicago.

The Canada yew, *Taxus canadensis* Marsh., is limited to the northwestern part of the state where it occurs on the high banks of the Rock River in Winnebago County; on limestone cliffs at Warren and Apple River Canyon State Park in Jo Daviess County; on limestone rocks along Carroll Creek, near Mount Carroll, Carroll County; on limestone cliffs at White Pines Forest State Park, Ogle County, and on a hillside over limestone rocks along Franklin Creek, near Franklin Grove, Lee County. There are also a few individuals on the walls of the canyons of Starved Rock and Mathison State Parks, La Salle County and a small stand persists on the rocky banks of Rock Creek, Kankakee County.

The northern white cedar, *Thuja occidentalis* L., is a tree which has a very scattered distribution in Illinois, being limited to a very few individual trees with sparse reproduction and growing in widely separated stands. A few occur along the high bluffs of the shores of Lake Michigan in Lake County and there is a small stand near the city of Elgin in Kane County. In La Salle County it is to be found on the rocky bluffs of the shores of the Illinois River and on the sides of the canyon slopes of Starved Rock State Park.

Although the mountain ash, *Sorbus americana* Marsh., is used for ornamental planting, it is very rare as a native forest tree. Waite found it near Oregon, Ogle County, in 1888, but there seems to have been no other record for fifty years until it was rediscovered by G. N. Jones and the writer near Oregon in 1944. There they found a fair sized tree and three saplings.

The little bunch-berry, *Cornus canadensis* L. seems to have entirely disappeared from Chicago and Cook County where it was collected between 1880 and 1900, and at Oregon, Ogle County, where it was found in 1888. The only collections which seem to have been recorded during the present century are those of E. J. Hill, 1905, in the bog at Wauconda, Lake County, and of D. T. Ries, in 1942, on one of the canyon walls in Starved Rock State Park. It may be looked for and probably found in some of the bogs of Lake and McHenry Counties.

The round-leaved dogwood or circinate dogwood *Cornus rugosa* Lam. (*C. circinata*) is a northern species that occurs scattered through Lake

County and has been collected in Lee County. Other collections seem to be absent from all herbaria but it should be sought (and probably found) between Lake and Lee Counties.

Many of the Ericaceae are absent or rare in Illinois. The large-leaved shin leaf, *Pyrola elliptica* Nutt. seems to have disappeared, although several collections were made in Cook, Lake, and Winnebago Counties about 1880. The round-leaved wintergreen, *Pyrola rotundifolia* var. *americana* (Sweet) Fern. has recently been collected in Lee County in moist woods along Franklin Creek.

There seems to be a single collection each of *Kalmia glauca* L., the pale laurel, and of *Andromeda polifolia* L. There are no records of their occurrence during the past 40 years.

There seems to be only a single record of the pinesap, *Monotropa hypopitys* L., a close relative of the little Indian pipe. It was collected in Elk Grove, Des Plaines, Cook County, in 1943 by Gordon Pearsall.

The aromatic wintergreen, *Gaultheria procumbens* L., has been reported only from Cook County where it seems now limited to a very small stand near Elk Grove, Des Plaines, Cook County.

The Canada blueberry, *Vaccinium canadense* Kalm. was formerly found by Babcock and by Hill in Cook County (1882, 1887) but it has doubtless long since disappeared. It now seems to be limited to Starved Rock State Park, La Salle County, and Castle Rock, Ogle County, where it occurs on St. Peters sandstone.

Two related species, the high blueberry, *Vaccinium corymbosum* L. and the large cranberry, *Vaccinium macrocarpon* Ait. are limited to bogs. Very few collections of them seem to have been made at any time. The former has been collected from a bog near Volo, Lake County and the latter from a bog near Lake Villa, Lake County. They both probably occur in other bogs in Lake and McHenry Counties.

A SIMPLIFIED LABORATORY METHOD OF TESTING THE TOXICITY OF FUNGICIDES

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The need of increased food production is greater today than it has ever been. Science is meeting this need by three approaches: (1) giving the plant its optimum growing conditions; (2) improving the germ plasm through the science of genetics; and (3) protecting the plant from its enemies by means of protective fungicides and insecticides. Regardless of the perfection of the first two factors a plant cannot obtain its maximum productivity if the last factor is neglected.

For years Bordeaux mixture and lime-sulphur have been the two standard protective fungicides. Recently, however, chemistry has supplied many new complexes designed to improve the protective efficiency of fungicides. The production of a new fungicide requires careful testing before it can be recommended for public use. Testing of fungicides has generally been done in the field on the plants to be protected, but this procedure is costly in both time and materials. The work described in the present paper was undertaken to determine whether a laboratory method could be devised that would permit reliable comparisons to be made as to the relative toxicities of both old and new protective fungicides. The method proposed herein does not claim to eliminate field trials, but it will give some information as to the relative toxicity of a preparation to fungus spores before it is sprayed on the plant to be protected. It is recognized that a method in which glass slides are used is limited in its scope, since reactions between the fungicide, the leaf, and the fungus cannot be tested, however these reactions can be studied by field tests which should naturally follow.

The possibility of fungicide testing in the laboratory is not new. Numerous methods have been suggested, such as bringing the fungus into contact with the fungicide in suspension or in solution- (Burrill) (Hamilton et al.) or in an agar medium (Palmiter). These methods may have rendered useful information but they do not test the toxic relationship of the spore and a dry deposit of the fungicide such as used in the field. The first investigators to evolve a method on this basis were Reddick and Wallace in 1910. Their method proposed the spraying of slides or cover slips with an atomizer until a visible uniform deposit was attained. Such a spore-fungicide relationship was an improvement over the methods previously mentioned, however its limitation centered around the difficulty of getting sufficient uniformity of deposit to give a uniform toxic response of the spores.

An improvement of the dry-deposit method has been proposed by Montgomery and Moore, East Malling Research Station, in 1938, and by the author in 1939. The researches of both were conducted simultaneously and the fundamental principles embodied in both were based on the idea that comparative results could best be obtained if an accurately measured quantity was uniformly

distributed over a delimited area. The toxicity of a preparation was determined by finding the range between a completely toxic and a nontoxic dilution. From this range of dilutibility a number of factors may be determined regarding a fungicide as: (1) its potency in relation to other fungicides; (2) its potency according to different methods of mixing; (3) the effect of varying pH upon its toxic range; (4) how other compounds as spreaders or insecticides might affect its range and; (5) the adhesiveness of the fungicide after the slides have been exposed to weathering, especially to rain.

The materials required for this method of testing include glass slides on which small circles have been etched, a finely calibrated pipette (a serological pipette or glass tube may be drawn to a fine bore and marked so that the same quantity of the dilution will be delivered each time), bell jars, petri-plate lids, four-inch squares of window glass, cultures of fungus in a sporulating condition, and the top or bottom of a moist chamber.

The circles on the slides were etched in the glass by covering the slides with a coating of paraffin and then stamping out three equidistant circles 15 mm. in diameter with a large cork-borer. These grooves were then filled with hydrofluoric acid (care must be taken to go around the circle with a sharp-pointed object to insure uniform contact of the acid with the glass). After the paraffin was removed the slides were cleaned so they were grease-free, otherwise uniform distribution of the fungicide within the circle would not have been possible. This was done by dropping them into concentrated chromic acid cleaning solution. After thoroughly rinsing in tap water and finally in distilled water they were wiped dry and placed with the circles down on typing paper. Before turning them over to receive the fungicide any traces of oily film that might remain on these areas was removed by vigorously rubbing the surface on the typing paper. The heat generated by the friction made possible the complete removal of the slightest trace of oily film which might have remained.

By means of a serological pipette (or other pipette with a fine bore) a uniform quantity was delivered within each circle. The amount to be delivered should be determined and must never vary in the slightest if toxic comparisons are to be made. Five hundredths of a milliliter was found to be satisfactory in that it was sufficient to completely cover the circle, while the surface appeared level over the entire circle. Uniformity of depth is important to insure the same toxic response over the entire area. Care must be exercised during the process of measuring the fungicide. Before delivering the measured quantity all droplets adhering to the outside should be removed by pulling the pipette through some soft absorbent paper, such as Kleenex. In addition it is important to guard against any carry-over when changing from one dilution to another or from one fungicide to another. The pipette should be carefully cleaned with hot dilute chromic acid cleaning solution, then thoroughly rinsed before using it with a new fungicidal preparation. When going from one dilution to another with the same type of fungicide, the pipette should be rinsed with distilled water and then filled and emptied several times with the new dilution before delivery is made. After the various dilutions have been delivered and spread to the etched border they are appropriately

marked with a glass marking pencil and spread to dry. The range of dilutions will of course vary depending on the fungicide and the kind of spore being tested.

The next step in this process is in getting a uniform spore distribution over the same area. Fungus spores or conidia should be chosen on the basis of their parasitic importance and their ability to grow and produce abundant spores on culture media. *Venturia inequalis, Alternaria solani* and *Monilinia fructicola* have been found to be suitable for these tests. Just as it is important to get a uniform spray distribution, it is also important to get an equally uniform spore distribution. The spores used should be grown on the same kind of culture media and should be the same age when tested. By placing the scrapings from the surface of the mat in distilled water and vigorously stirring the water the spores or conidia are dislodged from the mycelium. By straining the mixture with several thicknesses of cheesecloth a mycelium-free spore suspension can be obtained. To obtain the desired number of spores per unit area the above-mentioned spore suspension is diluted and examined microscopically, until the desired number (within a range, as 10-15 under high power), is obtained. The quantity of spore suspension delivered on each area must be held constant and the spore suspension should be agitated with a stirrer when the quantity is taken out to eliminate any settling factor. Sufficient suspension is taken so that the entire delimited area is covered uniformly.

After the encircled areas are covered with the spore suspension the slides are ready for incubation. This is best accomplished by placing the slides in petri-plate lids which have sufficient diameter to accommodate two slides (the slides may be placed in the lids before the spore suspension is added, thus eliminating the danger of dropping or spilling the suspension over the edge of the circle). The petri-plate lids are next stacked in a moist chamber the bottom of which is covered with paper toweling and soaked with water. The plates are easily and safely stacked by placing a 4-inch square of window glass between the petri-plate lids. A large bell jar is then set over the stack with its base resting on the soaked paper toweling in the moist chamber. By adding water to the area outside of the bell jar an air-tight seal is made, and the spore suspensions within the bell jar are subjected to a saturated atmosphere. These units are incubated in darkness at room temperature or as near 20° C. as possible for 48 hours.

Germination results are determined by microscopic observation from each of the three areas on the slide, thus checking in triplicate. Toxicity may be recorded according to the following arbitrary standards: (0) normal germination, similar to the check plates in each bell jar, no visible evidence of toxicity; (1) any visible evidence of toxicity, such as a shortening of the germ tube or contortion of it, decreased percent of germination; (2) if only a few very short germ tubes, merely protuberences existed it was classed very toxic; (3) the concentration which permitted no germination was considered the toxic limit.

If greenhouse facilities permit, further testing of the fungicide may be carried on to determine its phytocidal effect on the foliage. Preparations may appear promising from the standpoint of its toxicity to the spore, but may also be very toxic or otherwise unsafe to the foliage of

the host plant. Theoretically, a fungicide should first protect the foliage, should be adhesive to the leaf surface, and should be compatible with supplementary insecticides. For these preliminary studies apple, cherry or peach seedlings lend themselves readily. The fungicide may be applied at varying concentrations and subjected to varying environmental conditions such as varying the temperature and moisture content of the air or mineral nutrients. Indoor tests such as described should not be considered conclusive, but may furnish a clue which can be investigated further by field tests.

THE LITERATURE OF ILLINOIS NATURAL HISTORY AND GEOGRAPHY

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This is a report of the Committee on Ecological Bibliography, of which Part I was published in 1935. It tells what recent work has been done for Part II in assembling citations pertinent to the biology of Illinois, with annotations if these are necessary or helpful. Since many descriptions published long ago were not included in Part I, it also attempts to evaluate some of this older literature, especially as it throws light on the very considerable changes that have taken place in the physical and biological environment of Illinois. Some of our economic problems, as flood control, soil conservation, and wildlife management, may be more intelligently met if there is sufficient awareness of the trends of change.

The older accounts of conditions in the more extensive prairies emphasized their wetness during spring and part of the summer. For about a century roadmakers, engineers, and farmers have labored to accelerate drainage, especially on uplands, with the result that flood problems seem to be progressively aggravated in the bottomlands. Occasional droughts and water-supply shortages are troublesome during the drier years, perhaps more so now than formerly. Yet the records of earlier floods and droughts make it less certain that we may anticipate continued increase of such difficulties. To enable us to see what actually has taken place, chronologies are being prepared listing such recurrent matters as floods, droughts, severe winters, tornadoes, glaze-storms, and outbreaks of destructive insects, with references to articles describing these events.

Non-recurring changes in the prairie environment have likewise occurred and are continuing. The human ecology of prairie farming illustrates this admirably. The early trials of various thorny plants to serve as living fences settled upon Maclura as the best hedge material; of recent years the eradication of osage hedges has somewhat enlarged effective areas for cropping. Evidently the windbreak value of hedges is less esteemed now than formerly. The articles and short notices in such journals as the Prairie Farmer, bearing on this and similar developments, are too numerous to be separately cited, but a collation of references to such subjects has been made, so that particular trends are made evident. Miss Marguerite Simmons of the University of Illinois Library staff searched through many earlier volumes of the Prairie Farmer to assemble this material. In so doing she brought to light a number of articles of direct value to biologists.

Plant and animal life of our native prairies have been so nearly completely destroyed that prairie biology in Illinois seems almost to be history, rather than a living subject. Interest in reconstituting some small samples of near-prairie grassland is increasing. Dr. V. E. Shelford and Dr. R. F. Fuelleman are now engaged in such a project near Urbana. Such efforts will depend partly upon the ideal striven for. Some prairie

ecologists maintain that truly undisturbed prairie consisted almost wholly of the dominant grasses, with accompanying herbs few. They believe that degree of disturbance is suggested by degree of abundance of flowering dicot herbs. Other prairie ecologists, supported by many published descriptions of prairie vegeta tion, consider that there were within a given district different types of prairie and many variations within a type, flowering herbs being abundant in some types. If the latter view is correct, almost any made-to-order combination of native prairie grasses and herbs will resemble some formerly existent natural prairie growth.

Though the old-time descriptions, even those by botanists, are disappointingly lacking in detail as to composition of prairie, they do throw much light on this same question of grasses versus dicots. They clearly show that from middle Indiana to the Missouri River flowering herbs were conspicuous in most of the prairies. Page citations to these old descriptions are now available in considerable numbers.

We shall probably never have a basis for judging whether or not a particular bit of prairie is "undisturbed," nor how much changed from its "original" condition. We can never properly evaluate the influence of bison, elk, and deer on Illinois vegetation, nor know all the factors responsible for the oak openings and barrens of former times. Before 1800 the old French settlements on bottom prairies along the Mississippi, and village sites and camping places of Indians in upland prairie regions, were largely occupied by blue-grass. Where prairie was frequently grazed or trampled, the old writings frequently state, blue-grass, in places with white clover, became established. After settlement by Americans from eastern and southern states, grazing was usual about every farm and village. Farm animals were generally unconfined; their disturbing influence reached to some distance. The wettest prairie flats which last were brought into cultivation were commonly used for grazing by large herds. Some areas were converted to blue-grass long before they could be plowed. This was true also of the vicinity of certain groves, which afforded shelter to cattle that grazed over the surrounding prairies. Milk's Grove in northwestern Iroquois County, and Pigeon Grove east of Loda, were so used. In earlier days the Indian ponies ranging from such places as Indian Grove in Livingston County or Parish Grove in Benton County, Indiana, similarly had had their effects on prairie vegetation before botanists were able to study it. The older county histories are of great value in elucidating these changes.

The old question whether settlement encouraged the spread of forest by the stopping of prairie fires, so commonly stated as the principal basis for the fire theory of causation of treelessness, is touched on in many writings old and new. Such statements should be read critically. Highly circumstantial accounts of fires eating into forests, or of new forests following settlement, were written by travelers who passed through the state on one brief tour. They may turn out to be second- or third-hand variants of the authors' readings of earlier works. It is notable that Timothy Flint, one of the most dependable writers on the early middle west, says much about prairie and little or nothing about prairie fires. Several questions are pertinent: Did fires actually diminish

timber areas? To what extent did fires terminate abruptly after a district was settled? Did any other influences incident to settlement possibly help in establishing tree seedlings where prairie had been? The relatively few passages in the literature that positively bear on such questions are more significant than most descriptions of fires and of forest spread imputed to their cessation. Specific references to such passages are being added to the bibliography of Illinois ecology.

Turning to current publications, the established journals, serials such as the Transactions of the Illinois Academy, and publications of the State Surveys, add their quotas each year to the literature of biology and geography of Illinois. The American Midland Naturalist has become a leading source of materials on the midwest country.

In addition to those mentioned in earlier reports, the following have helped materially in adding to the bibliography: George W. Bodecker, Clarence G. Golueke, Elizabeth Frederick, Marguerite Simmons, Edna L. Meadows, and Richard Walker.

Of about 2000 titles of books and articles examined, 700 are completed for Part II of the bibliography, with annotations and partial analysis if these are necessary; 700 are assigned to the "Supplement," which will not be published; the other 600 need additional checking or collation. About 800 articles and books for which citations are on hand have not yet been examined. Completed titles and supplement, on cards arranged by authors, are available for consultation at Room 211, Natural History Building, Urbana.

CHEMISTRY

THE META MONOHALOGENATED BENZOTRIFLUORIDES*

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Information was needed in the Survey laboratories on the properties of a complete series of monohalogenated benzotrifluorides. This information was obtained by synthesizing the *m*-fluoro-, *m*-chloro-, *m*-bromo-, and *m*-iodobenzotrifluorides. The object of this paper is to describe the synthesis of the bromo and iodo derivatives, and to compare also some of the properties of all of these compounds.

All of the compounds were synthesized from *m*-aminobenzotrifluoride by well known diazotization reactions. The *m*-fluoro[1] and *m*-chloro[2] derivatives were prepared as described in the literature. The bromo and iodo compounds were prepared by the Sandmeyer reaction. Simons[3] prepared the bromo compound by the direct bromination of benzotrifluoride; he reported only the boiling point and gave no analysis.

Table I gives the physical properties of these compounds and some closely related analogs. In all cases, the meta halogen derivatives of benzotrifluoride have lower boiling points than the corresponding toluene analogs. By comparison to the simple monohalogen benzene compounds, the first member, *m*-fluorobenzotrifluoride boils higher than fluorobenzene; however, this order gradually reverses with increasing molecular weight as iodobenzene boils higher than *m*-iodobenzotrifluoride. The densities are higher and the index of refraction values are lower when compared to toluene analogs or the simple halobenzenes.

In general, these compounds are quite stable, are fairly volatile, and have a mild odor. The iodo derivative will slowly darken on standing, but will not undergo the Ullmann reaction to form a biphenyl with copper bronze at 250-270° C.

The authors are indebted to Mr. H. S. Clark, microanalyst, for the analyses given in this investigation.

EXPERIMENTAL

m-Bromobenzotrifluoride. — The general procedure given in Organic Syntheses[4] for *p*-bromotoluene was used for the synthesis of *m*-bromobenzotrifluoride.

A mixture of 20 grams of crystallized copper sulfate, 10 grams of copper turnings, 77 grams of sodium bromide, 8.2 cc. of concentrated sulfuric acid, and 500 cc. of water was refluxed for 3-4 hours. A small amount of sodium bisulfite was added to complete the reduction and obtain a pale yellow solution.

* Published with the approval of the Chief, Illinois State Geological Survey.

TABLE 1.—PHYSICAL PROPERTIES OF META MONOHALOGEN SUBSTITUTED BENZOTRIFLUORIDES

Compound	M. P. °C	B. P. °C	Density 20° C	$n^{20}D$
$C_6H_4(CF_3)(F)1,3$[2]	−81.5°	100.9	1.289/25°	1.398/25°
$C_6H_4(CH_3)(F)1,3$	−110.8	116	0.9972/13°	1.4691
C_6H_5F	−41.9	84.8	1.024	1.4646/22.8°
$C_6H_4(CF_3)(Cl)1,3$[2]	−55.4	138.4	1.336/25°	1.4466/25°
$C_6H_4(CH_3)(Cl)1,3$	−47.8	162	1.0722	1.5214/19°
C_6H_5Cl	−55	132	1.1066	1.5247
$C_6H_4(CF_3)(Br)1,3$	.....	151–53*	1.632*	1.4738*
$C_6H_4(CH_3)(Br)1,3$	−39.8	183.7	1.4099	1.551
C_6H_5Br	−30.6	155–56	1.4991/15	1.5597
$C_6H_4(CF_3)(I)1,3$	.....	173*	1.887*	1.5198*
$C_6H_4(CH_3)(I)1,3$	.....	204	1.698	.....
C_6H_5I	−31.4	188.6	1.832	1.6214/18.5°

* Data determined by authors.

With stirring, 80.5 grams of *m*-aminobenzotrifluoride[1] was added to a solution of 54 cc. of concentrated sulfuric acid in 500 cc. of water, and digested with heating. After the amine hydrosulfate was cooled to 10°, it was diazotized with a solution of 40 grams of sodium nitrite in 60 cc. of water and the temperature not allowed to exceed 20°. The diazonium sulfate solution was filtered.

The hydrobromic acid-cuprous bromide solution in a flask arranged for steam distillation was heated to boiling. By means of a separatory funnel, the diazonium solution was slowly added to the copper solution while a vigorous current of steam was passed through the mixture. The aqueous distillate was made alkaline with dilute sodium hydroxide solution and the *m*-bromobenzotrifluoride was separated from the water layer. The crude product was consecutively washed with cold concentrated sulfuric acid, water, dilute alkali, water, and dried over anhydrous magnesium sulfate. The crude product weighed 71 grams. This product was distilled and 50 grams (44.5 percent of the theoretical amount) boiling at 151-153° was obtained.

Analysis calculated for $C_7H_4F_3Br$: C, 37.36; H, 1.79; Br, 35.51. Found: C, 37.49; H, 1.79; Br, 35.14.

m - Iodobenzotrifluoride. — To a solution of 200 cc. concentrated hydrochloric acid in 200 cc. of water, 80.5 grams of *m*-aminobenzotrifluoride was added and then digested by heating. After cooling the amine hydrochloride mixture to 5° C, it was diazotized with a solution of 40 grams of sodium nitrite in 60 cc. of water. The diazonium solution was filtered. To the clear filtrate, a solution of 89 grams of potassium iodide in 90 cc. of water was added in small amounts with stirring. Nitrogen was vigorously evolved and the rate was controlled by the addition of the potassium iodide solution. After the mixture had been allowed to stand overnight, it was heated on a steam cone for one-half hour to complete the decomposition. The heavy oily layer was separated, made slightly alkaline with dilute sodium hydrox-

ide solution, and steam distilled. The crude iodo compound was decolorized with dilute sodium thiosulfate solution, and dried over anhydrous magnesium sulfate. The crude product weighed 118 grams. It was distilled under reduced pressure giving a main fraction of 110 grams (81 percent of the theoretical amount) boiling at 73-75°/23 mm (173° at atmospheric). Redistillation gave a product boiling at 82-82.5°/25 mm.

Analysis calculated for $C_7H_4F_3I$: C, 30.91; H, 1.48; I, 46.66. Found: C, 30.74; H, 1.47; I, 46.69.

SUMMARY

m-Bromo and *m*-iodobenzotrifluoride were prepared from *m*-aminobenzotrifluoride by the Sandmeyer reaction in 44 and 81 percent yields, respectively.

The physical properties of the *m*-fluoro-, *m*-chloro-, *m*-bromo-, and *m*-iodobenzotrifluorides were tabulated and compared.

m-iodobenzotrifluoride will not undergo the Ullman biphenyl synthesis with copper at 250-270° C.

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GEOGRAPHY

SETTLEMENT PATTERNS OF ILLINOIS

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The use of the term "settlement" usually calls to mind a colony or a backwoods village—the pioneer or incipient stage of a regional economy. Again it may have sociological implications such as the settlement house of a congested urban district. In this paper the term is applied to the cities, towns, and villages of a state which has long since reached the stage of maturity. Although the individual cabin was an important factor in the original settling of the state, because of a somewhat changed function, the individual farmstead or isolated rural home is not included.

NATURE AND FUNCTIONS OF SETTLEMENTS

Within the limits of the state of Illinois, which, by virtue of its area of about 56,400 square miles, is the twenty-third largest state, lives the third largest population (7,897,241 according to the 1940 census). Of this number 5,809,650 or 74 per cent reside in towns and cities of 2500 or more, and four-fifths of those live in one metropolitan district. When towns and villages with populations less than 2500 and unincorporated places are included an imposing array of settlements results. There are 220 towns and cities with populations over 2500. Two of these rank among the some six hundred cities of the world that have populations of 100,000 or more. There are more than 800 towns and villages with less than 2500 and innumerable unincorporated villages.

Settlements come into existence, grow, and flourish because they perform certain functions. When the need for those functions no longer exists the settlements diminish and may ultimately disappear. There are ghost towns even in Illinois. Economic, social, and political services are rendered by the settlements. Some, notably the saxicultural towns, produce wealth directly from the natural environment. Thus cities, towns, and villages are the product of cultural adjustments made to two natural environmental components—site and situation. Site qualities include such items as terrain, drainage, bedrock, soil, native vegetation, and the like at the immediate site of the settlement, whereas qualities of situation include space, distance, and time. The concept of location, other than the latitude and longitude of a point, implies qualities of situation.

It is obvious that every settlement is the product of some type of association, wise or otherwise, with some type of natural environmental site, the details of which differ from place to place. The structure, however, of each settlement is basically the same. It is safe to say that, with the possible exception of the residential su-

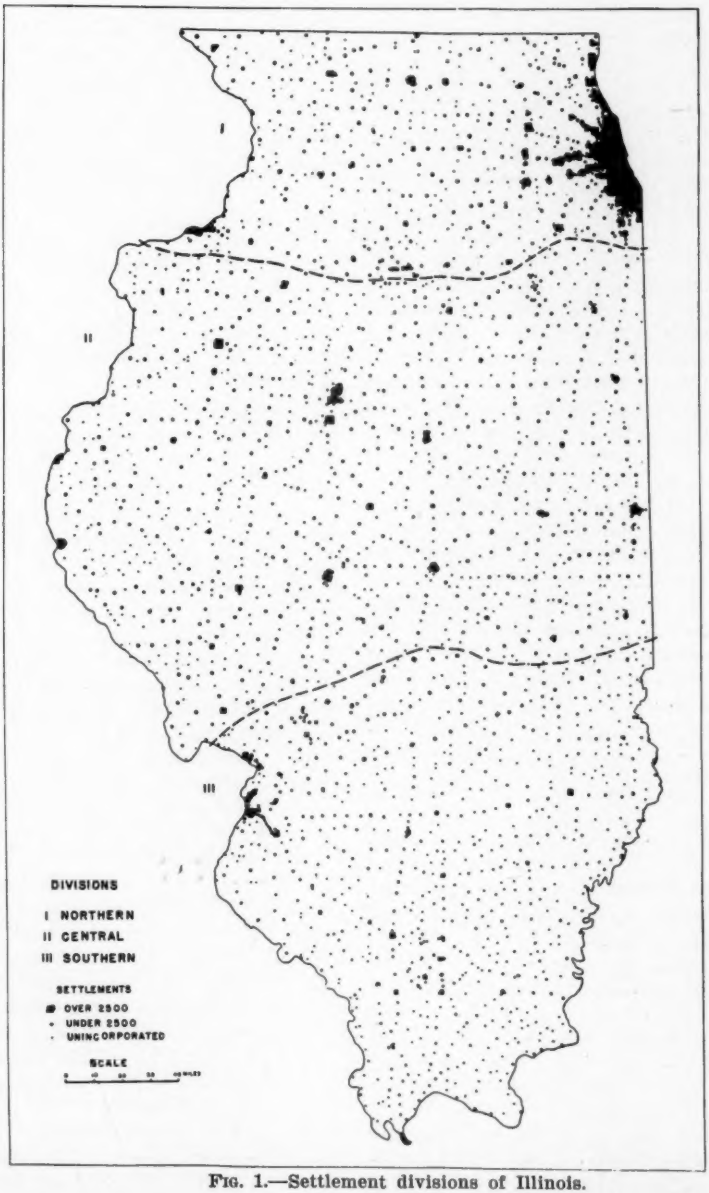

FIG. 1.—Settlement divisions of Illinois.

burbs of the large metropolitan districts, every settlement consists of several well-marked concentric zones. The larger the settlement the more perfectly developed are the zones. As interesting as an investigation of the relation of settlement structure to the site qualities might be, the very number prohibits a thorough investigation on a state-wide basis. On the other hand the space arrangement of cities, towns, and villages produces a series of patterns which are the results of both site and situation associations and which are worth geographic consideration without the necessary detailed investigation of the former. Perhaps some term such as the "gross structural settlement pattern" might be introduced to imply the space arrangement and relation of cities, towns, and villages in the light of the general association of each to its natural environment.

In an area as lacking in sharp physical contrasts as the state of Illinois it would seem logical to expect a similarity of pattern throughout the state. Casual inspection of the map (Fig. 1) indicates the lack of similarity, suggests variations of a logical nature, and raises the question of agreement or the lack thereof between settlement and natural environmental patterns.

TYPES OF SETTLEMENT PATTERNS

There are two basic types of settlement patterns in Illinois. The first, the alignment, is ubiquitous and is chiefly the product of a route of transportation. Different areal arrangements of alignments result in different patterns. The convergence of several alignments on a common center, often a large town or city, produces a radial pattern, whereas parallel alignments result in a checkerboard pattern. In this state the township has been an important factor in crystallizing the above patterns composed of settlements spaced six miles apart.

The second type is the group of which there are two distinct classifications in Illinois. One is the metropolitan association, which in one sense is the end product of a radial pattern of national or even global proportion, and the other is a cluster. The former is composed of a major city and numerous associated cities, towns, and villages. Closely spaced short alignments with a definite focus on the major city characterizes the metropolitan association. On the other hand the cluster is a closely spaced indiscriminate arrangement of towns and villages of about the same size.

SETTLEMENT DIVISIONS

As the map (Fig. 1) indicates, with the exception of metropolitan associations, the various types of settlement patterns are distributed over the entire state, yet enough areal similarity is present to justify the delimiting of three settlement divisions. A line from the Mississippi River, just below the confluence of the Rock River, to the great bend of the Illinois River and thence to the Indiana boundary, following the south side of the Illinois River, separates the northern division from the central. In the same fashion the central and southern divisions are separated by a line from the Mississippi, just below the confluence of the Illinois, to the nearest part of the Shelbyville moraine which it follows to the Indiana boundary.

Each division is differentiated by dominant conditions of settlement pattern. The northern division is characterized by a variety of patterns changing rapidly from east to west across the state. The central division is made distinctive by a

series of overlapping radial patterns centering on a dozen or more large towns and cities. In the southern division long alignments, thickening here and there into well-marked clusters, dominate the pattern.

NORTHERN DIVISION

Settlement patterns of the northern division are diverse; some are in accord with and others are at variance with the diversity of natural environmental conditions of the area. Five north-south districts comprise the northern division. They are: the metropolitan district, the moraine border district, the Rock Valley district, the northwestern district, and the Mississippi border district (northern segment).

The metropolitan district. — The metropolitan district is very sharp and distinct. It is an area of cities with only a scattering of villages near the outer margin. The district terminates sharply in the Fox Valley urban alignment (Elgin, St. Charles, Geneva, and Aurora) and the lower DesPlaines Valley towns (Lockport and Joliet). With the exception of the above alignments, the entire metropolitan district is associated with recent Wisconsin glaciation. The site of Chicago is the sand plain beyond which are the lake border and Valparaiso moraines over which the associated cities and towns spread. With the exception of the DesPlaines Valley, railroads and super highways radiate in all directions with little regard for the site. Qualities of situation are much more significant in a highly developed urban district, especially where there are no sharp contrasts in site conditions.

The Mississippi border (northern segment).—The Mississippi border and the Rock Valley alignment are settlement patterns that conform closely to the natural environment. The width of river and the nature of the valley bottom and associated bluffs are such that east-west traffic is interrupted at the Mississippi. At four points trans-Mississippi paired settlements (East Dubuque-Dubuque, Savanna - Sabula, Fulton - Clinton, and Rock Island-Moline-Davenport) mark the crossings. The rest of the alignment is composed of small towns and villages on the highways and railroads that follow the valley.

The Rock Valley district.—Although the Rock River is not wide enough to be a costly obstacle to transportation, an alignment of settlements spaced roughly at ten mile intervals has developed. Each of the larger towns and cities, the largest of which is Rockford, is a crossing for a railroad or major highway radiating from the Chicago metropolitan district. In turn the alignment is further strengthened by valley highways. At the confluence of the Rock and the Mississippi the two alignments focus on Rock Island and Moline.

The northwestern district. — Between the Mississippi and Rock rivers is the northwestern district. Here one well-developed radial pattern centering on Freeport occupies the drift-covered portion of the district, whereas a cluster of villages and towns are characteristic of the dissected unglaciated portion.

The moraine border district.—The remaining district, which extends from the metropolitan district to the Rock Valley alignment, is an indiscriminate mixture of alignments, radials, and clusters. Highways and railroads, radiating from the Chicago metropolitan district, cross the area along which the well-marked alignments are developed. The closely spaced town and city alignment on the southern edge of the district is the upper Illinois Valley. A north-

south system of moraines crosses the district, in fact the Bloomington moraine roughly bisects it. In general, the spacing of settlements and the resulting patterns are not concerned with the moraines in this district. Radials and checkerboard groups characterize the central portion, whereas a closely spaced cluster occupies the glacial lake section of the northeast, and a couple of weakly developed alignments occupy the great, flat valley of the Green River. Drainage, perhaps, has been a significant factor in the development of the settlement pattern over much of the entire district. This is a portion of the Grand Prairie through which small groves were scattered. As the names of many of the towns and villages suggest, these groves became settlement sites. Good drainage and protection from the wind seem to be important factors in the development of groves in the prairie. The great swamps of the Green Valley were generally avoided, thus accounting for the weak alignments of villages on the railroads that now cross them. The alignment and radial pattern of the rest of the district, like the patterns of the rest of the state, has been crystallized by the railroads and highways, however, groves were significant items in the sites in the early development of these settlements. The fact that most of the forests occupied the better drained and dissected land adjacent to the streams, accounts for the location of most towns on or near streams, many of which are too small to be of any economic value, with the possible exception of small mill sites.

CENTRAL DIVISION

Although a system of overlapping radials characterizes the settlement patterns of the central division, enough diversity is present to make possible the recognition of four distinct districts. The Illinois Valley alignment separates the eastern district from the western, and the Mississippi border district (central segment) constitutes the fourth district.

The eastern district.—The eastern district is characterized by a series of overlapping radials the centers of which are large towns and cities spaced at 40-mile intervals with lesser centers at shorter distances. Decatur, Springfield, Bloomington, and Danville are among the major centers, whereas, Jacksonville, Lincoln, Pontiac, Streator, Kankakee, Champaign-Urbana, and Mattoon are some of the lesser centers. Peoria, the major city of the Illinois Valley alignment, is also a radial center. A general settlement pattern of this type is a logical one to develop on a flat, productive, agricultural land. The fact that a variety of natural environmental conditions are present seems to be of no great significance. An irregular line from Shelbyville to Peoria marks the boundary between Illinoian and Wisconsin glaciation. There seems to be no marked difference in settlement patterns in the two parts. As was also true in the northern division, there does not seem to be a marked relationship between settlement patterns and individual moraine patterns. Bloomington and Champaign-Urbana are the only large towns on the moraines, although Decatur is very close to the Shelbyville moraine. There is little evidence of alignments following glacial moraines, in fact there is some indication of a lack of settlements on the moraine sites. The open portion of the pattern on the northern edge of the district on the Marsailles moraine is an area of that type. Paris, Mattoon, Charleston, and a number of smaller towns and villages following the inner edge of

the Shelbyville moraine is the best morainic alignment in the division. Three of the alignments of the Peoria radial follow the general trend of the Bloomington and Shelbyville moraines, although they do not actually occupy them. However, it is possible that it is more of a prairie problem than it is of land form. With the exception of the southwestern portion, the district lies within the Grand Prairie and, as was pointed out earlier, settlements were made in or near groves which, for the most part, occupied the better drained land. The location of most of the settlements, both large and small, on or near streams is a relationship to the forest. Bloomington and Champaign-Urbana on their morainic sites are exceptions to the stream pattern adjustments, yet there were groves near both.

In several spots, notably the forested area adjacent to the Illinois-Mississippi confluence, and the coal mining area on the inside of the great bends of the Illinois and of the Illinois-Kankakee, the radial pattern is broken. In the former the valleys of the Illinois and Mississippi break the ease of travel in all direction, and, since the major crossings are just to the north or south, this area has assumed a checkerboard pattern. On the other hand, the coal mining towns and villages form quite irregular clusters on the uplands south of the trough of the Illinois valley.

Point should also be made of the fact that deposits of loess varying in depth from two to more than twenty-five feet cover most of the district. The loess cover is thickest just east of the lower Illinois Valley, diminishing in thickness eastward and northeastward to an area in the northeast where the loess is not identifiable. In the zone where the inequalities left by glacial activities are covered by loess, the radial pattern of settlements is best developed.

The western district.—The western district repeats the patterns and relationships of the eastern on a reduced scale. One major radial, centering on Galesburg, is related to the loess covered Illinoian drift in the prairie portion of the district. The southern portion, the forested triangle between the Illinois and the Mississippi rivers, whose situation is out of focus with major crossings of both valleys, possesses a checkerboard pattern of towns and villages comparable to the embayment across the Illinois Valley.

The Illinois Valley district.—Separating the eastern and western districts is the well-marked alignment of the Illinois Valley. From Pekin to the great bend of the valley the pattern consists of a double alignment of closely spaced towns and villages each on a river terrace site. This district, known as the middle Illinois Valley, was among the first to be identified and investigated geographically. Peoria, as the major city in the alignment and the second largest city in the state, is also the center of a radial reaching both the eastern and western districts. Since the Bloomington and Shelbyville moraines, as well as the Illinois Valley, focus on the site of Peoria, it is here that the closest agreement of a large radial pattern to the natural environmental patterns is found. In addition to the middle and lower Illinois Valley alignments are those from several other directions, three of which follow the general trend of the Bloomington moraine from the north and southeast, and the Shelbyville moraine from the south.

From Pekin southward another double alignment of towns and villages follows the lower Illinois Valley. The valley is wide and poorly

drained, especially above the glacial border, and there the alignments follow the valley sides, reaching the river only at intervals of 25 or 30 miles. At these points, numbering five in all, both railroads and highways bridge the valley. Below the glacial border, which follows the eastern wall of the valley, small towns and villages are connected across the Illinois by ferry. At the Illinois - Mississippi confluence the settlement pattern is limited to one small town.

The Mississippi border district (central segment).—Two alignments of towns and villages make up the settlement pattern of the Mississippi Valley. A closely spaced alignment follows the valley wall where the alluvial bottoms are wide, whereas a widely spaced alignment of bridge and ferry towns line the river. At several points where the valley bottom narrows the alignments meet. It is there that large towns, Quincy and Warsaw, have developed, and major river crossings have been established.

SOUTHERN DIVISION

The southern division is composed of four districts: The Mississippi border district(southern segment), the Wabash border district, the northern district, and the southern district.

The Mississippi border district (southern segment).—A well-marked alignment of towns and villages follows the bluff side of the Mississippi Valley, and a secondary alignment of widely spaced towns and villages occupies the water front below the East St. Louis cluster. In this segment of the valley there are only two bridge crossings of the river, both of which are in the extreme southern part.

In the northern part of the southern segment the East St. Louis-Alton cluster marks the convergence of a number of alignments on the St. Louis metropolitan area, one of the major crossings of the Mississippi.

The southern district. — Weak alignments and clusters of small towns and villages characterize the settlement patterns of the southern district. From Shawneetown to Cairo a closely spaced alignment follows the Ohio River, whereas a second alignment occupies the Cache depression with a few scattered villages on the loess area between. In the maturely dissected section between the glacial boundary and the alluvial lands of the Mississippi embayment, the settlement pattern consists of three irregular alignments of little villages. There is only one town in the area with a population greater than 2500. The drainage of the area is divided into north-flowing and south-flowing streams by a well-marked east-wise divide. On this divide is an alignment of towns bearing such names as "Mountain View," "Alto Pass," and "Tunnel Hill." On both sides of the divide are the other alignments, the individual villages occupying sites in the little tributary valleys.

The Wabash border district.—An alignment of small towns and villages follows the Wabash Valley. Mt. Carmel, the largest town on the river, marks one of the three bridge crossings. There are no Illinois towns at the other two. The alignment leaves the valley where it is joined by the Embarrass River (locally Ambraw), thus the settlement pattern is conspicuously meager on the wide alluvial bottoms at the Ohio-Wabash confluence.

The northern district.—The remaining district is large and the numerous towns and villages present a settlement pattern of well-marked

alignments. A series of four or five alignments of closely spaced settlements cross the area in an east-west manner. These straight lines are, of course, railroad and highway routes from southern Indiana that converge on the Mississippi crossing at East St. Louis. A few north-south alignments cross the district, thus developing radials. The one developed on Centralia is perhaps the best. Between the slightly converging alignments a number of little villages are scattered somewhat at random. Like the eastern district of the central division, the loess covered ground-moraine presents a smooth, featureless surface over which straight alignments could easily be built. Unlike the Grand Prairie to the north, this area was forested and, therefore, there is no settlement-grove relationship. The rivers of the area, the Kaskaskia, Little Wabash, and Embarrass flow in wide alluvial valleys to the southwest and southeast. Their swampy valleys and vegetation-choked channels made them undesirable for transportation or settlement. Thus they are not occupied by settlement alignments, and the only towns in the valleys are those that are a part of the major highway and railroad alignments.

At two points, however, the alignments thicken into well-developed clusters. One is on the northwestern border of the division and the other is in the south near the drift-border. Both of these, like the clusters in the northern edge of the central division, are saxicultural groups.

CONCLUSIONS

In the above presentation certain ideas appeared with such regularity that they might well be enumerated. Among these is the varied but recurring theme that settlement patterns conform to some natural environmental patterns and seemingly neglect others. Settlement patterns make a sharp adjustment to major drainage patterns, a partial adjustment to vegetational cover, lithic materials, and the like, and seem to disregard surface features.

The second recurring point is the importance of situation. Routes of transportation, railroads and highways, and their interruptions at large rivers are the crystallizing factors of the settlement patterns. Relationship to situation is especially significant. The combination of a variety of natural environmental elements, which permits maximum occupance and presents minimum obstacles to free movement, is the natural environmental complex to which settlement patterns in Illinois are related.

From an areal point of view the comparative importance of site and situation clearly stand out. The northern and southern divisions, dominated by alignment settlement patterns, are the products of the situation of the metropolitan districts of Chicago and St. Louis, whereas the central division, just beyond the focus of both, possesses the radial pattern of the productive, agricultural plain. Further investigation, however, of the functional relation of the various settlements to their site and situation conditions would bring into sharper focus geographically the regional qualities of Illinois.

GEOLOGY

COMPARISON OF SEVERAL DECORAH HORIZONS IN NORTHERN ILLINOIS

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The shales and shaly limestones between the Galena and Platteville formations, by reason of their distinct lithology and fauna at the type locality, have been given the formation name Decorah[1]. This formation is widespread in the Mississippi Valley, and changes radically in thickness and appearance from outcrop to outcrop. As recognized by Aberdeen[2] and defined by Kay[3], the formation contains two members, the Guttenberg (Guttenberg, Iowa) and the Ion (Ion, Iowa). The Guttenberg includes part of the "Oil Rock", so designated by the miners, which has been described by Grant and Burchard[4]. At Decorah, Iowa and northward the Guttenberg is a greenish shale. However, in the type area one mile north of Guttenberg and southeastward for thirty miles, the member is distinguished by gray to b r o w n, sublithographic thin-bedded fossiliferous limestone with interbedded chocolate-colored shale interspersed between wavy bedding planes. The overlying Ion is characterized by calcareous shale and argillaceous limestone near the type section in northeastern Iowa, but it becomes a dolomite and is scarcely distinguishable from the basal Galena formation forty miles southeastward in the vicinity of Dickeyville, Wisconsin.

Three locations have been chosen for comparison where the Decorah horizons are not readily separated from the underlying Platteville and the overlying Galena formations. They are: (1) Rockford Quarry near the northwest limits of the city of Rockford, SE. ¼ sec. 15, T. 44 N., R. 1 E., Rockford Quadrangle; (2) roadside quarry at Lowell Park, three and one-half miles north of Dixon, Illinois, in the SE. ¼ NE. ¼ sec. 18, T. 22 N., R. 9 E., Dixon quadrangle; and (3) along the north bank of the Vermillion River, Lowell, Illinois, SE. ¼ sec. 8, SW. ¼ sec. 9, T. 32 N., R. 2 E., LaSalle and Ottawa quadrangles.

The basal Decorah is difficult to delimit because the Spechts Ferry, the upper member of the Platteville, is variable in thickness and lithology. In the three areas studied the Spechts Ferry member either is not recognizable or is not present, so that the upper Platteville "glass rock" zones come in contact with the Gut-

[1] Calvin, Samuel, Geology of Winneshiek County: Iowa Geol. Surv., vol. 16, p. 84, 1906.
[2] Aberdeen, E. J., the location of the break between the Galena and the Platteville limestone: M.S. Thesis, Northwestern University, 1931.
[3] Kay, G. M., Ordovician Mohawkian Ostracoda: Lower Trenton Decorah fauna: Jour. Paleontology, vol. 14, p. 234, 1940.
[4] Grant, U. S. and Burchard, E. F., Lancaster-Mineral Point Folio: U. S. Geol. Survey Geologic Atlas No. 145, p. 6, 1907.

FIG. 1.—Rockford City quarry, SE. ¼ sec. 15, T. 44 N., R. 1 E., Rockford quadrangle. The head of the hammer rests on a thin shale bed, unit 5 of the measured section.

tenberg member of the Decorah. Lithologically, and even faunally, no striking difference exists between the two. Eastward from the type area, the upper part of the Guttenberg-Ion sequence as defined by Kay[5] is a dolomitic limestone or dolomite, each outcrop varying in lithology. A species of a *Prosopora*, a usable marker in northeastern Iowa, has not been reported in the localities named. Gradational contacts between the upper Decorah and Galena are common in northern Illinois. In subsurface studies, the Decorah formation is recognized by its color, density, chert, and its shaly facies[6]. In these outcrops examined the shaly partings, though present, are not numerous.

A detailed measured section of the Rockford quarry follows.

The Spechts Ferry member of the Platteville formation either is not represented or is not recognizable. Beds 2-8 inclusive are regarded as the lower Decorah. The only lithological likeness to the type section Guttenberg member of the Decorah formation is in beds 5 and 6, which show a few shaly partings and wavy uneven bedding planes. Characteristic fossils are *Columnaria halli*, *Streptelasma corniculum*, and small *Strophomenids*. The Ion member in this quarry is even more difficult to recognize, if present at all. Beds 7-11 are sparingly fossiliferous and lithologically do not vary appreciably

[5] Kay, G. M., The Orodovician system in the Upper Mississippi Valley: Guidebook of the 9th Ann. Field Conference Kansas Geol. Soc., p. 289, 1935.

[6] Willman, H. B. and Payne, J. N., Geology and mineral resources of the Marseilles, Ottawa, and Streator quadrangles: Illinois Geol. Survey, Bull. 66, p. 65, 1942.

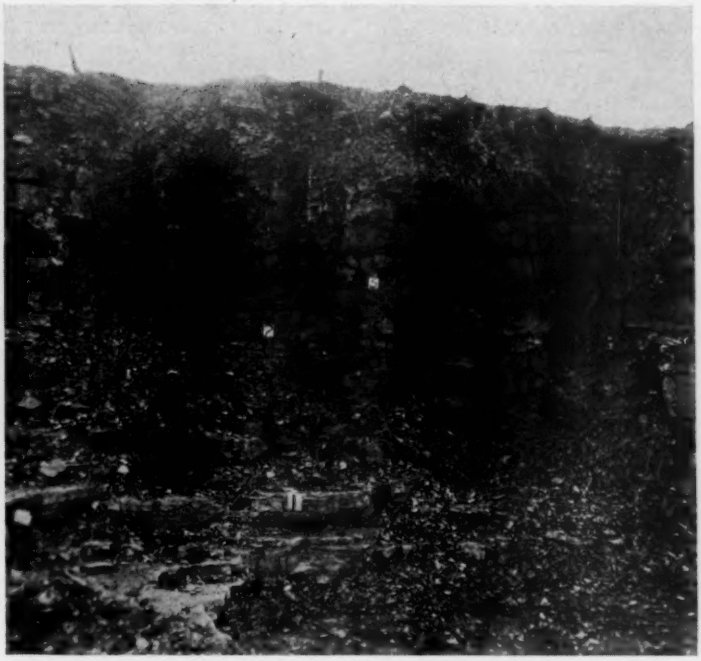

FIG. 2.—Roadside quarry 3½ miles north of Dixon, Illinois, at Lowell Park, SE. ¼ NE. ¼ sec. 18, T. 22 N., R. 9 E., Dixon quadrangle. The numbers are at the upper limits of the units.

from the Galena, which probably is present from No. 12 upward, if not from No. 9 upward. The Ion, if present, cannot easily be distinguished from the overlying Galena.

The Decorah sequence recognized at Rockford may be summarized as follows. Chert is common in beds 3, 8 and 9; the rock is a dolomite; fucoids are plentiful, but abundant near the top of bed 7; wavy beds and shaly partings can be distinguished; in the lower beds small amounts of carbonaceous shale give a bluish color.

A section restudied and measured at Lowell Park, near Dixon, is presented.

The Lowell Park section north of Dixon exhibits the transitional nature of the Decorah. Knappen[7] has ealled these beds the Lowell Park member of the Platteville, but states that they are of Decorah age. Here, as at Rockford, the Spechts Ferry member is not recognizable.

Bed No. 1 of the section probably is the uppermost "Blue"[8] of the Platteville. The rock is a sublithographic dolomitic limestone. Beds 2

[7] Knappen, R. S., Geology and mineral resources of the Dixon Quadrangle: Illinois Geol. Survey Bull 49, p. 54, 1926.
[8] Knappen, R. S., op. cit. p. 33.

(1) *Rockford Quarry (formerly Carrico Quarry), Rockton Avenue near the northwest city limits, SE. ¼ sec. 15, T. 44 N., R. 1E., Rockford Quadrangle, Illinois.*

		Thickness Ft.	In.
Galena formation			
15	Dolomite, buff, weathered, rotting; chert bands prominent in lower part*	25	
14	Dolomite, thin-bedded with chert; weathers buff	15	
13	Dolomite, buff, weathered; many gastropods; chert bands near top	7	6
12	Dolomite, buff, beds two to four inches thick, shaly partings prominent; fossiliferous with *Receptaculites* in the center of zone	5	8
Galena? or Ion member of Decorah formation?			
11	Dolomite, massive, gray-blue; forms upper blue bed of the quarry	2	5
10	Dolomite, thin-bedded, shaly	2	6
9	Dolomite, buff, massive, cherty, sparingly fossiliferous	5	3
Lower Decorah			
8	Dolomite, buff, beds three to six inches thick, very little chert	2	7
7	Dolomite, buff, beds about four inches thick, fossiliferous; *Strophomena* common and Streptelasma in basal twelve inches, fucoids	3	2
6	Dolomite, massive, blue-gray, carbonaceous, sparingly fossiliferous; *Streptelasma* near base; a few shaly partings	2	
5	Dolomite, shaly, iron-stained, wavy, fossiliferous; Echinoderm fragments, *Streptelasma*, and *Vanuxemia* present		3
4	Dolomite, buff, cherty, beds three to six inches thick; *Streptelasma* present	2	2
3	Dolomite, buff, thin-bedded, cherty, fucoidal; *Streptelasma*	3	6
2	Dolomite, gray, carbonaceous, dense	2	10
Platteville formation			
1	Dolomite, gray, dense, fossiliferous; *Trochonema beloitense* and *Lophospira bicincta* common	9	2
	Covered, water in quarry pit pumped to low level.		

* estimated

(2) *Roadside quarry and exposures three and one-half miles north of Dixon, Illinois, SE. ¼ NE. ¼ sec. 18, T. 22 N., R. 9 E., Dixon Quadrangle.*

		Thickness Ft.	In.
Galena formation			
	Covered cherty dolomite ¼ mile south along road, above No. 6.		
6	Dolomite, medium to thick beds, buff, cherty, dense, calcareous at base becoming more dolomitic near top with definite shaly parting below	5	10
Decorah formation			
Ion member			
5	Dolomite, calcareous, buff, fucoidal, cherty bands, thin to medium beds, silicified *Cqlumnaria* and bryozoans present	7	6
4	Limestone dolomitic, massive, buff; a few chert nodules; *Columnaria* and *Streptelasma corniculum* present	6	8
Guttenberg member			
3	Limestone, dolomitic, buff to gray, thin-bedded, uneven, wavy; massive in upper eighteen inches	6	4
2	Limestone, buff, dense, 4 to 6 inch beds some of which are uneven and wavy; shaly partings, calcite vugs, small amounts of chert present; fossiliferous, *Streptelasma* present	6	10
Platteville formation			
1	Limestone, gray-blue, buff on weathered surfaces, beds four to eight inches thick, dense, glassy, bluish wavy shaly parting at top; pyrite present	2	7
	Covered; Platteville limestone along banks of stream 25 yards north and approximately 20 feet below the level of the road-side quarry.		

and 3 of the section are the equivalents of the Guttenberg member, based on lithologic similarities. Uneven dense wavy beds with shaly partings are characteristic, though not as easily detected as in the type area because of the variable thickness of the beds. Silicified fossils include *Streptelasma, Liospira, Zygospira,* and a few Echinoderm fragments. Beds 4 and 5 probably are the Ion. Lithologically these beds have little in common with the Ion of northeast Iowa. Number 5 is a striking fucoidal unit which is seen in the abandoned quarries in the northeast limits of the city of Dixon. This fucoidal zone may correlate with the number 7 horizon of the Rockford section. Number 6 is gradational into the typical Galena dolomite.

The suggestive Decorah horizons at Lowell Park may be summarized as follows. A definite lithologic change from Platteville below, but with gradation into the Galena above; gradual change from a limestone near the base to a dolomite above; chert is common throughout, but more plentiful in bed 5; fucoids range widely but are profuse in bed 5; *Streptelasma* and *Columnaria* are common fossils.

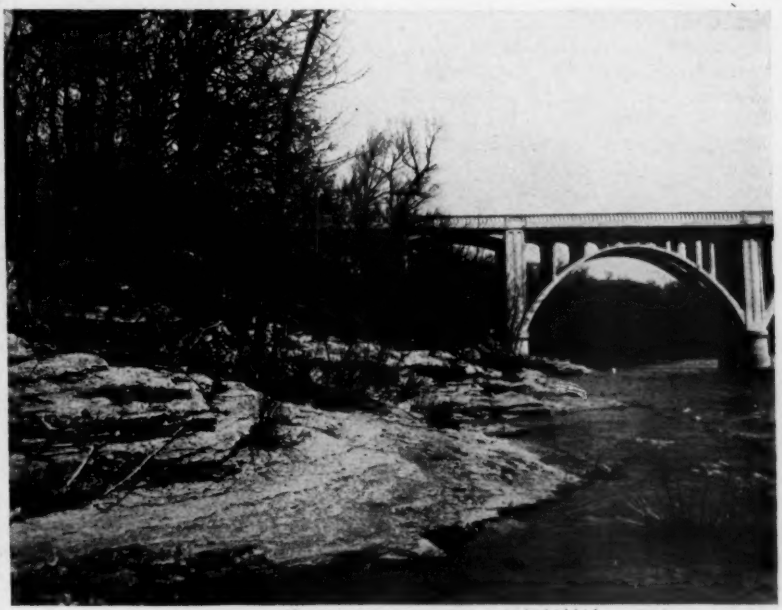

FIG. 3.—Decorah limestone along the Vermillion River at Lowell, Illinois, SE. ¼ sec. 8, T. 32 N., R. 2 E., LaSalle quadrangle. The black arrow is close to the Decorah-Galena contact, base of unit 12.

Ten miles southeast of LaSalle, the Vermillion River in cutting its valley across the LaSalle anticline exposes rock of Trenton age. This exposure may be followed upstream for nearly two miles from a point one fourth mile west of the old highway bridge. Beds dip from two to four degrees to the southwest, but east of the new highway bridge they are broken into great blocks and are greatly disturbed. Inaccuracy in measurements are possible, but the numbered beds do not appear to be repeated. The measured section (3) is given.

Bed No. 1 near the bend of the stream is the lowermost Decorah or the upper Platteville. Beds 2 through 6 are dense gray fossiliferous limestones with sparse amounts of chert. In lithology, as well as in the common occurrence of *Sowerbyella, Dalmanella,* and small *Rafinesquinas* these beds correlate with the Guttenberg of southwestern Wisconsin[9]. A lithologic break occurs at the base of bed No. 7, the rock becoming crystalline and massive upwards. The crystalline facies and the characteristic mottling, the presence of large *Rafinesquina* cf. *jeffersonensis* Bradley, and the many ramose bryozoans resemble Kimmswick lithology and fauna. The Ion horizon, as at Rockford and Dixon, is difficult to delimit. It possibly can be separated from the Guttenberg on lithologic grounds, but faunally the break is not distinct. Upward, the Decorah-Galena is gradational. A marked break occurs at the base of bed No. 12. Above the rock is less coarsely crystalline, more sparingly fossiliferous, and more massive. A zone of *Receptaculites* occurs eleven feet above the base of bed No. 12.

It is the opinion of the writer that the Galena and Decorah at this location represent a transitional phase between the Galena of northern Illinois and the Kimmswick of western Illinois and Missouri. The Ion member (beds 7-11) are correlated with the basal Kimmswick. The Decorah of Missouri probably should be correlated with the Spechts Ferry member or even lower in the Platteville, largely on the basis of the abundant presence of *Pionodema subaequata* in it, but it may extend into the Guttenberg.

[9] Bays, C. A. and Raasch, G. O., Mohawkian relations in Wisconsin: Guidebook of the 9th Ann. Field Conference Kansas Geol. Soc., p. 299, 1935.

TABLE OF ANALYSIS

	SiO_2	CaO	MgO	P_2O_5	R_2O_3	CO_2
Rockford No. 6*	3.8	29.8	20	tr.	1.09	45.34
Lowell Park No. 1.....	4.5	40.2	10.3	tr.	1.89	43.15
" " No. 2.....	4.84	49.7	2.81	tr.	.75	41.93
" " No. 6 (bottom)....	5.60	26.90	18.90		.79	47.78
" " No. 6 (top).....	2.50	30.20	20.40	tr.	.69	46.20
Lowell No. 3**.....	2.50	51.10	3.59		.49	42.35
" No. 11.....	.50	55.80	.59		.30	42.80
" No. 22.....	1.30	55.50	.17		.70	42.35

* Numbers refer to unit numbers of measured sections.
** 250 yards east of No. 5 of measured section, in bed of Vermillion River.

(3) *North bank Vermillion River, Lowell, Illinois, SE. ¼ sec. 8, SW. ¼ sec. 9, T. 32 N., R. 2 E., LaSalle and Ottawa Quadrangles.*

The higher beds dip westerly under the alluvium at about an angle of 3°.

		Thickness ft.	In.
	Galena formation		
22	Limestone, similar to No. 21, *Receptaculites* at top	4	5
21	Limestone, buff, mottled, massive, solution pockets on weathered surfaces	2	6
20	Covered	1	
19	Limestone, massive, buff, mottled, solution pockets	1	4
18	Limestone, buff, beds four to eight inches thick	4	6
17	Limestone, gray, mottled, appears thin-bedded and spalls off on weathering	5	11
16	Limestone, gray-buff, medium to thin beds, fossiliferous with many ramose bryozoans	8	11
15	Limestone, massive, mottled, solution pockets, weathers buff	5	10
14	Limestone, gray, beds three to six inches thick; *Strophomenids* and ramose bryozoans profuse; chert	7	6
13	Limestone, buff-gray, mottled, solution pockets on the weathered surfaces; *Receptaculites* at the base	7	6
12	Limestone, buff-gray, mottled, thin beds, calcite vugs near top, becoming crystalline downward; small orthoceratites	10	10
	Decorah formation		
	Ion member		
11	Limestone, gray-buff, thin-bedded, mottled, crystalline; ten inch crystalline band prominent at base; fossiliferous, Echioderm stems, large ramose bryozoans, *Streptelasma corniculum* and *Dalmanella* common, faunal break at top	2	2
10	Limestone, massive, porous, mottled, pitted, Echinoderm fragments; two prominent crystalline bands eighteen inches apart in center, fauna similar to No. 11 above	6	6
9	Limestone, buff, mottled, crystalline	2	2
8	Limestone, buff-gray, massive, *Dalmanella* common	4	10
7	Limestone, heavy ledges, dolomitic, mottled, crystalline, porous, calcite vugs, fossiliferous; *Sowerbyella* and large *Rafinesquinas* cf. *jeffersonensis* Bradley common. *Rhynchotrema increbescens* at base	8	2
	Guttenberg member		
6	Limestone, thin-bedded, crystalline, fossiliferous, spalls off on weathered surfaces, upper beds shaly	5	10
5	Covered, probably not over a few feet at most; area of uncertain dips.		
4	Limestone, medium to massive beds, cherty, fossiliferous; common fossils are *Sowerbyella*, *Dalmanella*, *Rafinesquina*, and trilobites including *Isotelus* and *Ceraurus*	12	6
	Note: About 300 yards east of No. 4 in a small ravine, three and one half feet of the same rock is exposed dipping two degrees to the west. The rock is limestone, gray, thin-bedded, cherty and fossiliferous; *Dalmanella* and *Sowerbyella* common; may represent the same horizon as No. 4 above.		
3	Dolomite, buff, cherty, nonfossiliferous	2	
2	Limestone, dense, glassy, beds three to six inches thick, slightly wavy; similar beds in the stream's edge a few yards to the west are cherty, and contain many small *Rafinesquina* as well as *Streptelasma* cf. *profundum*	2	2
	Decorah or Platteville?		
1	Limestone, dolomitic, massive		10
	Covered, near bend in river approximately one mile east of the new Highway bridge.		

The Decorah formation at Lowell shows the following: Dense gray fossiliferous limestones at the base becoming more massive and crystalline upward; a moderate amount of chert in the lower beds and in bed No. 14; lower beds crowded with *Dalmanella;* the Ion member is difficult to delimit; upper horizons, especially the strikingly mottled beds, are suggestive of Kimmswick.

Acknowledgment.—The author desires to express his sincere appreciation for the helpfulness of J. R. Ball of Northwestern University in the field studies, and to William Beher, an assistant in the Chemistry Department of North Central College, for his aid in the chemical analyses.

PENNSYLVANIAN STRATIGRAPHY OF PART OF SOUTHERN INDIANA[1]

DONALD W. FRANKLIN
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INTRODUCTION

By H. R. WANLESS

During more than a year of field work in southern Indiana Mr. Franklin studied most of the outcrops of the Pennsylvanian from the West Franklin limestone on down in Perry, Spencer, Warrick and parts of Dubois and Pike counties. He worked out a composite columnar section of the lower Pennsylvanian in these counties which is reproduced in this paper (Fig. 1). Although the outcrops in these counties have been studied by earlier investigators[2] Mr. Franklin worked out the detailed succession of the lower Pennsylvanian below coal IIIa in greater detail than previous students of the area had done. The succession from the West Franklin limestone down to coal IIIa is reasonably well known and is similar to that farther north in Indiana and in adjacent parts of western Kentucky. The succession below coal IIIa differs from that in other parts of the Eastern Interior basin in that fossiliferous marine limestones and cherts occur at a larger number of positions than elsewhere. Mr. Franklin's section shows 9 limestones below coal IIIa. In most other parts of the basin there are not more than two marine limestones below Illinois coal No. 2, Indiana coal IIIa and their correlatives. These marine zones are the Seahorne and Seville limestones of western Illinois, the Stonefort and Curlew of southern Illinois and western Kentucky, and the Silverwood[3] and Minshall of Indiana. Although Mr. Franklin refers one of the limestones to the Curlew it seems wiser to designate it by the local names used in this report until it has been traced to Union County, Kentucky where the type exposure of the Curlew is located.

The part of the Eastern Interior basin described in this paper is nearer to the Appalachian coal field than practically all other parts of this basin. It is worthy of note that in southern Ohio there are several marine zones, the Hamden limestone, Putnam Hill limestone, Zaleski flint, Upper Mercer limestone, Lower Mercer limestone, Boggs limestone, Poverty Run limestone and Sharon ore which seem to be older than coal IIIa of Indiana. It seems possible that careful comparaive studies of the lithology and faunas of the marine limestones described by Franklin with those of southern Ohio may permit some exact correlations and thereby aid in matching the succession in the Eastern Interior basin with that of the Appalachian field. Recent studies of the ostracod faunas of the Ferdinand and Fulda limestones by Chalmer L. Cooper suggest that these faunas have no counterparts elsewhere in the Eastern Interior basin but seem to be equivalent to the Bostwick limestone member of the Barnett Hill formation (top of Morrow) and of the Dornick Hills group of the Wapannucka formation (base of Lampasas) Oklahoma. Al-

[1] Published with the permission of R. G. Kurtz, Ohio Oil Company.

[2] Ashley, G. H., The coal deposits of Indiana: Ind. Dept. Geol. and Nat. Res., Ann. Rept. 23, 1899, Dubois County pp. 1096-1156, Pike County pp. 1156-1230, Perry County pp. 1255-1298, Spencer County pp. 1298-1348, Warrick County pp. 1349-1398.
Fuller, M. L., Ditney folio, U. S. Geol. Survey Geol. Atlas, folio 84, 1902.
Wanless, H. R., Pennsylvanian correlations in the Eastern Interior and Appalachian coal fields. Geol. Soc. Amer. Spec. Paper 17, 1930, plate 1, columns 13 and 14, plate 2, columns 17 and 18, 1939.

[3] Alexander, J. W., Pennsylvanian geology of eastern Vermilion County, Illinois, northern Vermillion County, Indiana, and Warren and Fountain Counties, Indiana. Master's thesis at the University of Illinois, 1942, a name applied to the marine cap rock of Indiana coal II from outcrops along Coal Creek one mile east of Silverwood, southwestern Fountain County, Indiana.

TABLE 1.—CUMINGS' CLASSIFICATION OF PENNSYLVANIAN STRATA IN INDIANA

System	Series	Group
Pennsylvanian	Post-Allegheny	Wabash (250-300 ft.) Merom (75-90 ft.) Shelburn (150-235 ft.)
	Allegheny	Petersburg (180-300 ft.) Staunton (150-250 ft.)
	Pottsville	Brazil (60-80 ft.) Mansfield (80-300 ft.)

though several of the lower Pennsylvanian limestones described in this paper do not outcrop in Illinois, they probably underlie parts of the Illinois basin where they may be encountered in oil well drilling operations.

STRATIGRAPHY

By D. W. FRANKLIN

This paper presents a very condensed description of about 1000 feet of lower Pennsylvanian strata exposed in the two southern tiers of counties of Indiana. Its object is to show the relations of the various named strata to each other and to indicate typical outcrops where the more important key beds can be observed. No attempt is made to indicate the nature of the lateral variations in succession within the area or the outcrop patterns of the various subdivisions. The Troy coals, Fulda, Ferdinand and Grandview limestones and the Buffaloville coal are named here for the first time and the Holland limestone is redefined.

The lower Pennsylvanian of Indiana was divided into Divisions I to VII by Ashley[4], each division extending up to the base of the coal with the next higher number. Cumings[5] proposed a different classification (Table 1). This classification is followed in the present paper. The Wabash and Merom groups are younger than the youngest strata outcropping in the area of this report.

Figure 1 shows the succession of lithologic units recognized in southern Indiana. This figure shows 136 lithologic units aggregating 1092 feet. It should be recognized, however, that practically all of these beds vary in thickness within the area and that some of the beds are absent at some outcrops.

In this paper several of the more important outcrops are described and the type localities of newly named beds designated. The outcrops of beds younger than coal IIIa are not described since this succession had been worked out correctly by Ashley, Fuller, Wanless, and others and have been described in an earlier paper.

MANSFIELD GROUP

The basal sandstone of the Mansfield group is massive, coarse-grained and conglomeratic at some places.

[4] Op. cit.
[5] Cumings, E. R., Nomenclature and description of the geological formations of Indiana: Ind. Dept. Cons., Publ. 21, Handbook of Indiana Geology, pp. 519-530, 1922.

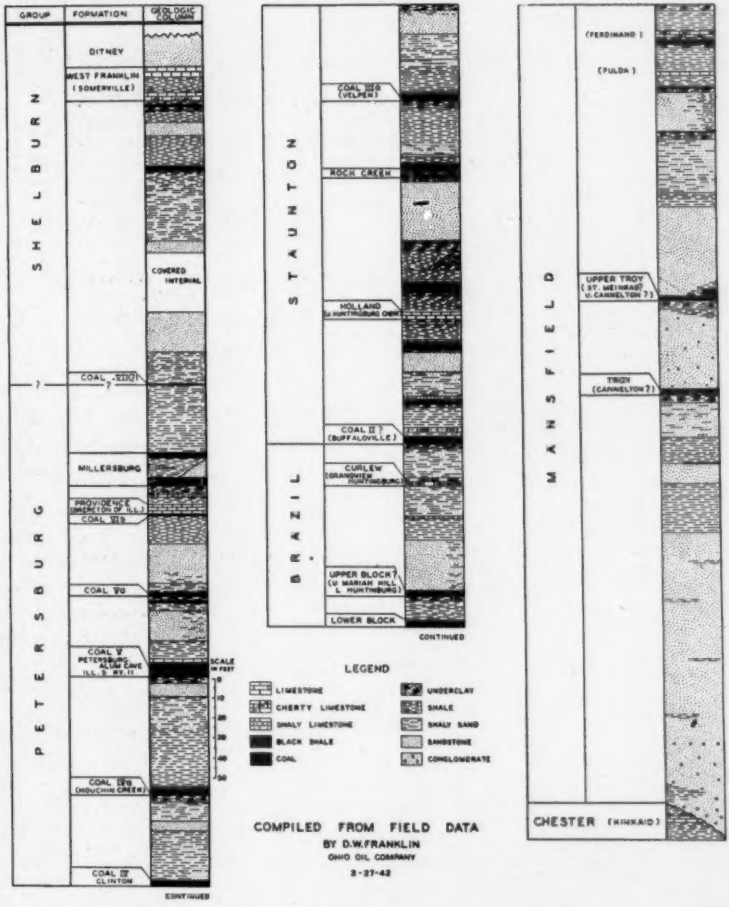

FIGURE 1.

It is probably equivalent to the Lower Conglomerate of the Caseyville of Kentucky. There are two prominent coals in the lower part of the Caseyville, known as the Lower Cannelton and Upper Cannelton near the town of that name and the Lower Troy and Upper Troy near that town in Perry County. The Lower Cannelton coal is characterized at some places by a black slaty canneloid shale roof. The lower part of the Caseyville is well exposed at LaFayette Spring, Perry County (Geologic section 1).

At a road-cut on State Highway

Geologic section 1.—Exposures in SW. ¼ Sec. 2, T. 7 S., R. 3 W., near LaFayette Springs, Perry County, measured by C. A. Malott and amended by D. W. Franklin.

	Thickness Ft.	In.
Pennsylvanian system		
Mansfield group		
Sandstone, massive, fine-grained, perhaps with shale breaks	13	
Coal (Upper Cannelton)	2	
Underclay	4	
Shale, gray, silty, with sandstone beds	25	
Sandstone, massive, fine-grained, with small quartz pebbles	15	
Shale, black, canneloid	0-3	
Coal, splint (Lower Cannelton)	3	
Underclay, slightly silty, light blue gray	3	
Sandstone, flaggy	35	
Shale, gray, silty (coal reported in literature)	36	
Sandstone, massive, fine-grained	32	
Shale, gray, silty	35	
Sandstone, medium-grained, sparkling, massive, cliff-forming, cross-bedded, with honeycomb weathering, bands of large quartz pebbles	50	
Mississippian system		
Limestone (Kinkaid) with associated shale		

Geological section 2.—Exposure in the S.½ SW.¼ SE.¼ Sec. 33, T. 4 S., R. 4 W.

	Thickness Ft.	In.
Pennsylvanian system		
Mansfield group		
Sandstone, fine-grained, micaceous, poorly exposed	10	
Concealed interval, some show of sandstone	5	
Sandstone, with abundant carbonaceous matter, fine-grained, very micaceous, medium-bedded to massive, ledge-forming	6	
Shale, black, soft		6
Limestone, medium blue gray, with abundant marine fossils	1	
Chert, black, mottled with white, leached, with numerous fossils, thickness variable, diamond-shaped jointing; locally in two beds (Ferdinand)	0-1	
Limestone, medium blue-gray, finely crystalline, with marine fossils (Ferdinand)	1	
Shale, light blue gray, soft	1	
Coal, bright, blocky	1	
Underclay, dark		6+
Concealed interval, some show of light blue gray shale	12	
Limestone, dark blue-gray, compact, brittle, with solution widened joints (Fulda)	2	6
Shale, light blue gray, soft, top poorly exposed, probably with coal... (Base of exposure)	6	

66 near Troy a massive sandstone a little above the Upper Troy coal contains marine fossils and plant debris and is probably a beach deposit. This part of the column is excessively variable. The St. Meinrad coal, mined near the town of that name in northern Perry County is tentatively correlated with the Upper Troy and Upper Cannelton.

The Fulda limestone is named from exposures along the road between Fulda and New Boston, eastern Spencer County and is well shown in the outcrop described as geologic section 2. It is dark blue

Geologic section 3.—Section at double incline mines and gully to the east in the center of the E.½ sec. 29, T. 4 S., 8., R. 4 W.

	Thickness Ft.	In.
Pennsylvanian system		
Brazil group		
Shale, medium to dark blue gray with ironstones	6	
Coal, slightly blocky (Upper Block?)	2	6
Concealed interval	10	
Coal, thinning to 18 inches southward, slightly blocky (Lower Block?)	3	
Concealed interval	5	
Coal		6
(Base of measured section)		

gray, dense, pure, brittle and sparsely fossiliferous.

The Ferdinand marine zone is about 15 feet above the Fulda limestone and consists of black shiny opaque chert with abundant casts of productids and dark blue gray argillaceous dull limestone. It is best developed northeast of Ferdinand in T. 3 S., R. 4 W. and west of the Ferdinand State Forest.

BRAZIL GROUP

The Brazil group was defined by Cumings as extending from the Lower Block coal of the Brazil district, Clay County up to coal II, a little above the Minshall limestone. The coals designated as Upper and Lower Block coals in this paper have not been traced to tie in with the Block coals of the Brazil district but are of approximately the same age. The Block coals are reported as follows from a double incline mine.

The Upper Block coal is also mined by the Mariah Hill Super Block Coal Company in secs. 19 and 20, T. 4 S., R. 4 W.

The Grandview limestone and an unnamed limestone 13 feet below it are well exposed in the Ohio valley bluff east of Grandview. The lower limestone is dark blue gray, dense and dull and the upper limestone light gray, crystalline and crinoidal with bedded chert. It is tentatively correlated with the Curlew of Kentucky. The type exposure of the Grandview limestone is described in the following measured section.

The Grandview limestone is 15 feet below the Buffaloville coal in the center of the NE. ¼ NE. ¼ sec. 21, T. 5 S., R. 5 W.

STAUNTON GROUP

The Staunton group of Cumings extends from the base of coal II up to the base of coal IV. Coal II is tentatively identified in this area with the Buffaloville coal mined commercially at the town of that name in Spencer County (Geologic section 5).

In addition to the limestone above the Buffaloville coal a dark blue gray dense limestone overlies a one-foot coal about 20 feet above this coal. The coal and limestone are not named, but are represented in Geologic section 6.

The name Holland limestone was applied by Ashley[6] but there are three limestones in the vicinity of Holland and it is not clear to which Ashley intended to apply the name Holland. It is here applied to the uppermost which is the most distinctive. The other limestones are not named. (Geologic section 7).

Geologic section 4.—Exposures along State Highway 66 East of Grandview in the Ohio River bluffs in the SE. ¼ NE. ¼ sec. 15, T. 6 S., R. 4 W.

	Thickness Ft.	In.
Pennsylvanian system		
Brazil group		
Limestone, light gray, finely crystalline, with bedded gray chert in nearby localities, large crinoid stems, massive, thickness to 5 feet (Grandview)	5	
Concealed interval	3	
Sandstone, thin bedded	4	
Concealed interval	6	
Limestone, dark blue gray, dense, dull		6
Sandstone, massive, cliff forming	13	
Shale, black, poorly bedded, hard, micaceous		8
Sandstone, massive to thin-bedded	8	
Siltstone, sandy, massive, with wavy carbonaceous laminae	2	
Coal (Upper Block?) in abandoned incline mine on Ohio River bluff just below this section		
Ferdinand limestone seen south of highway a little below the base of this section		
(Base of exposure)		

Geologic section 5.—Exposure in strip mine in the center of NE. ¼ NW. ¼ sec. 9, T. 5 S., R. 5 W.

	Thickness Ft.	In.
Pennsylvanian system		
Staunton group		
Shale, medium gray, calcareous at base	12	
Limestone, dark blue gray, argillaceous, fossiliferous	0-2	
Shale, dark gray, soft, calcareous, fossiliferous, poorly bedded, slightly silty, variable in thickness	3	
Shale, black, sheety to papery when weathered, unfossiliferous		6
Coal, blocky (Buffaloville)	3	6
Brazil group		
Underclay	3	

Geologic section 6.—Exposure southeast of Holland in the old Whitrock strip pit, center of S. ½ sec. 19, T. 3 S., R. 5 W.

	Thickness Ft.	In.
Pennsylvanian system		
Staunton group		
Shale, gray, blocky (27 feet below Holland limestone)	11	
Shale, dark gray to black, very calcareous, soft, very fossiliferous	1	
Limestone, dark blue gray to black, very argillaceous, fossiliferous	2	
Coal	0-4	
Underclay, blue gray	1	6
Concealed interval, gray shale reported	12	
Limestone, blue to gray, dense, with gray, opaque, porous weathering chert	3	
Coal (No. II or Buffaloville)[6]	3	

[6] Ashley, G. H., Supplementary report on the coal deposits of Indiana: Ind. Dept. Geol. and Nat. Res., Ann. Rept. 33, pp. 112, 129-131, 1909.

Geologic section 7.—Exposure near Holland in the SE. ¼ NE. ¼ NE. ¼ sec. 26 T. 3 S., R. 6 W.

	Thickness Ft.	In.
Pennsylvanian system		
Staunton group		
Sandstone, fairly massive	4	
Concealed interval	15	
Limestone, dark blue gray, dense		10
Shale, black, slaty, canneloid	3	
Coal, blocky	1	6
Underclay, dark blue gray, silty	1	6
Clay, coaly		4
Underclay, silty, hard, with hackly fracture	4	
Shale	2	
Chert, light gray to dark blue gray, ferruginous, with porous zone at top	1	
Limestone, light gray with brown mottling on weathered surface, dense, unconformity at base (Holland)	2	
Shale and clay, with limestone pebbles	1	6
Limestone, light gray, knobby, dense		6
Shale, light gray	3	

Geologic section 8.—Exposures at the center of the west line of the NE. ¼ NE. ¼ sec. 28, T. 3 S., R. 6 W.

	Thickness Ft.	In.
Pennsylvanian system		
Staunton group		
Shale, gray, with alternating black streaks, and show of thin-bedded sandstone close above	2	
Shale, black, slaty		3
Shale, drab gray, rather slaty		6
Shale, black, slaty		3
Coal	2	
Underclay	2	8
Shale, black, poorly bedded		5
Coal		5
Underclay	1	8
Coal		3
Underclay		4
Coal		2
Underclay, silty	1	
Coal	1	3
Underclay, brown	3	
Concealed interval	5	
Sandstone, massive, at base of exposure		

There are three or four thin and variable coals and two or three thin unnamed marine limestones between the Holland limestone and the massive sandstone beneath the Rock Creek coals. The lowermost of these limestones and coals is indicated in Geologic section 7 above the Holland limestone.

The Rock Creek coals consist generally of two closely spaced coals overlying the thickest and most massive sandstone in this part of the column. They are typically described in Geologic section 8 and are probably approximately equivalent to the Davis and Dekoven coals of western Kentucky.

Geologic section 9.—Exposures at the center of the south line of the SW. ¼ NW. ¼ sec. 28, T. 3 S., R. 6 W.

	Thickness Ft.	In.
Pennsylvanian system		
Staunton group		
Shale, silty, with thin sandstone beds	16	
Shale, silty, probably dark blue gray when fresh	10	
Concealed interval	8	
Limestone, dark blue gray to black, dense, very fossiliferous	1	
Shale, black, slaty, fissile, fossiliferous	2	6
Coal (Velpen or IIIa)	2	

Coal IIIa, the Velpen coal is overlain by a characteristic hard black slaty shale and thin dark gray fossiliferous limestone. It is correlated with coal No. 2 of Illinois and is one of the best stratigraphic markers of the area (Geologic section 9).

SILICA GEL AND WARSAW GEODES

PERCIVAL ROBERTSON
Elsah, Ill.

At the 1940 meeting of the Illinois State Academy of Science it was suggested that geodes such as occur in the Warsaw formation might have been formed from rounded masses of colloidal silica deposited on the sea bottom at the same time the sediment was being laid down.[1] It has been experimentally determined that globular masses of hydrous silica gel may be produced by letting a sodium silicate solution of from 1.17 to 1.38 specific gravity flow into a solution containing from about 16 to 26 percent commercial sodium chloride, and giving a rocking motion to the container. More dilute solutions of sodium silicate and more dilute solutions of salt produce flocculant masses of silica of indefinite shape but they do not generally produce rounded masses of silica gel. While such spherical masses can be produced by rocking alone, they can be molded by hand more rapidly.

When these masses of hydrous silica gel are removed from the solution they assume an oblate form and on slowly drying they shrink but slightly, and eventually leave a hollow shell of silica gel. When, to simulate natural conditions more closely, the spherical mass is placed in wet mud and dried slowly, a similar result has been obtained, namely a hollow shell of silica gel.

There is no intention to intimate that geodes have been formed by identical methods. There is no evidence known to the writer that sodium silicate in concentration even approaching those used ever may have been carried into the sea. But there are two points that seem to be of significance in the experiments. First, masses of silica gel can be produced in an ordinary salt solution when the salt is at concentration frequently found in salt lakes although not at the concentration usually found in the ocean. In this regard it may or may not be significant as Van Tuyl pointed out regarding the Warsaw formation: "that the member where it bears no geodes is in most cases, although not in all, fossilferous, while the geodiferous phase is, except for occasional limited seams of limestone, nearly destitute of fossil remains."[2] Second, when the somewhat spherical mass of hydrous silica gel is permitted to dry slowly a hollow shell of silica gel results.

In nature twin geodes are occasionally found. These consist of two (rarely more) chalcedony shells in contact, the surface of contact being essentially flat. One twin may be directly above the other when found in situ or they may lie side by side. Sometimes a thin film of kaolinite or some similar mineral separates the two shells. Each shell has developed its own individual cavity and they are not connected with each other. It has been very difficult to see how any process of solution and subsequent deposition of silica could account for such a phenomenon. It has

[1] Robertson, Additional notes on the Geodes of the Warsaw Formation, Trans. Ill. Acad. Sci. vol. 33, p. 168 (1940)
[2] Van Tuyl, Iowa Geological Survey, Annual Reports, 1921 and 1922, vol. XXX, p. 312.

been possible in the laboratory to produce two shells of silica gel in contact and each with its own separate cavity.

Mr. Walter Weiler carried out some of the experimental work here presented and appreciation is due him.

PHYSICS

TRANSMISSION OF SOUND BY A LIGHT BEAM

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In the May 1942 issue of the amateur radio magazine QST was an article by Stevens and Stevens on the transmission of sound by means of a modulated light beam. The light beam source was a flashlight or pilot light bulb modulated by a low power audio amplifier; the receiver, an audio amplifier with a photo-electric cell in-put.

This diagram shows suggested circuits for the transmitter and receiver. When a sound wave strikes the microphone, a minute electric current is set up in the microphone circuit. This current alters the potential on the grid of the 6J7 tube. The change in potential causes a change in the number of electrons reaching the plate from the filament. This results in a corresponding change in plate current which is of the same pattern as the current in the grid circuit but of much greater amplitude. The final amplifier tube further amplifies the signal in the same way. The current in the plate circuit of the 6L6G tube must pass through the primary of the out-put transformer. When it does so, it causes a varying magnetic field to be built up around that coil. As this magnetic field moves out from the primary and then collapses, it is cut by the secondary and induces an electro-motive force in that winding. This e.m.f. is added to or subtracted from the battery voltage which is lighting the filament of the flashlight bulb. Thus the voltage across the flashlight bulb varies in the same pattern as the sound waves which strike the microphone. Somehow this modulates the light. The light from the bulb is focused by means of suitable lenses on the photoelectric cell of the receiver. The cesium cathode of the photo tube sets free electrons when light shines on it. The greater the intensity of the light, the greater the number of electrons set free. The shorter the wave length of the light, the greater is the energy of the electrons which are set free. The electrons are drawn to the positively charged anode so that when light shines on the cathode a current flows in the photoelectric cell circuit. The magnitude of the current varies with the intensity of the light, and also with the frequency of the light. The light from the transmitter, varying as it does in the same pattern as the sound waves which originally fell upon the microphone, causes corresponding changes in the photo cell current which in turn changes the potential on the grid of the first amplifier tube. The signal is amplified just as it was in the transmitting amplifier and finally is reproduced by the speaker as sound.

Insofar as I have been able to determine, no one has yet proved just

what takes place in the flashlight bulb when its light is modulated. The intensity of the light given off by an incandescent filament depends upon the temperature of the filament. In order that the light beam be modulated at a frequency of 5000 cycles per second, for example, and it can be modulated at that frequency, it would apparently be necessary that the temperature of the filament vary, over a rather wide range, 5000 times in one second. To some experimenters it seems unlikely that this could take place.

One theory is that mechanical vibration of the filament caused the modulation in some way. If one taps the light source, a bell-like sound is heard in the receiver showing that mechanical vibration of the filament will in some way modulate the light. However, at the headquarters of the American Radio Relay League, the lamp was placed in a strong varying magnetic field which should have produced the same result. No sound was heard. It is the opinion of the headquarters staff there that some form of frequency modulation takes place, that the wave length of the light changes with variations in voltage.

My own opinion is that the temperature of the filament actually does change sufficiently to cause variation in the intensity of the light. I have found that if a low DC voltage is used to light the bulb modulation is very unsatisfactory even though the added signal voltage increases the average intensity of the light to full brilliance. However, if I put as high a voltage as the light can stand, then add a comparatively low signal voltage, the modulation is good. This seems to be in accordance with the law for radiation which states that the rate of radiation is proportional to the fourth power of the absolute temperature. If the DC filament voltage is such that the temperature of the light is high the rate of radiation is greatly increased, so that it may be possible for the filament to change its temperature sufficiently to modulate the bulb at high audio frequencies.

It may be that someone has determined just how the modulation takes place, but I have been unable to find a conclusive explanation. If I have the opportunity I plan to investigate further into the matter.

PREMEDICAL EDUCATION

TRENDS IN MEDICAL AND PREMEDICAL TRAINING

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I. WAR-TIME EXPERIMENTS IN EDUCATION

Educational experiments involving thousands of students preparing for a variety of activities related to the war are being conducted in many fields and at all levels. Educators face the serious responsibility of determining which features of the several war-time programs will warrant permanent incorporation into our educational systems.

The acceleration of the training is the most important of these experiments. The desirability of accelerating premedical and medical education, consistent with quality, is apparent from the fact that the average age of graduation from medical school has been between 26 and 27 years.[1] Before the graduate has completed hospital training and is able to support himself and a wife, he is upward of 30 or more years of age. A system which delays marriage to this extent is undesirable and any efforts which can be made to diminish the period of training are well worth permanent retention. The acceleration in medical schools seems most likely to justify retention after the war, perhaps in modified form, since acceleration in the medical schools involves no basic change in the curriculum or weekly work assignments but is effected by the elimination of the long summer vacations. It is very doubtful whether there is any adequate justification for compelling the student to devote one fourth of his time in medical school or in premedical college to non-academic activity.

It should be possible to reduce by at least two years the training period between the beginning of grammar school and the receiving of the M.D. degree. The elimination of long vacations would do much toward this end. Annual vacation periods of four or five weeks would seem adequate for students in college and medical school. Throughout the rest of life, particularly in the practice of medicine after graduation, vacations longer than this will be rare. There is no apparent justification for the traditional long college vacations.

The major obstacle to accelerated programs is economic. Acceleration would have been impossible in medical schools had not financial provisions been made to aid students who had formerly depended upon summer work to earn part of their expenses. Before the induction of medical students into the Army and Navy, loan funds were provided to assist needy students. In the year

[1] J.A.M.A., 109: 672 (Aug. 28) 1937.

ending June 30, 1943, $1,063,573 were lent to medical students by the federal government. This sum was supplemented by $977,700 from the Kellogg Foundation, making a total of about $2,000,000 for the year.

In a country which is spending—not loaning — this amount every quarter-hour of the day for war, the financial costs of any worth-while educational program must not be a deterrent. Loan funds are preferable to scholarships since the practice of medicine is among the reasonably remunerative professions and students preparing for this field should be willing to undertake a financial obligation in obtaining education for that profession.

Another kind of acceleration is involved in the premedical and other college-level training programs of the Army and Navy. In these, acceleration includes considerable increases in the daily and weekly work assignments of students. In some cases the assigned load is probably too excessive for a mastery of the material. Likewise the amount of time for elective work and the pursuit of special interests is too limited under such plans.

Another experiment which we should assess is the early selection of students for entrance into medical school. Under the Army Specialized Training Program selection for premedical studies and earmarking for subsequent entrance into a medical school are made early in the student's college career. Allowance is made for the loss of some men by academic failure before completion of the pre-professional program. In contrast to this, twelve to fifteen thousand students satisfactorily completed their premedical requirements each year before the war. Many hundreds of these were manifestly unfit for the study and practice of medicine, yet they were allowed to work toward this goal for two or three or four years expecting or hoping to gain admission to a medical school. More than half of the premedical students never entered a medical school since there are places in freshman medical classes for only about 6,000 students. Annually thousands of disappointed students were forced to readjust their life plans. Many solved the problem by entering unaccredited medical schools or professions related to medicine. Too many became teachers—sometimes of premedical or even medical students.

It will be important to know whether such early selection will be successful. Efforts and attempts should be made to retain the plan in modified form if possible with sufficient flexibility to provide for competent students who may make up their minds to study medicine relatively late in their academic careers. Much academic waste would be eliminated by such a program. It may be argued that a student who completes the premedical course and yet fails to obtain admission to a medical school has nevertheless had a valuable educational experience and may graduate from college with a reasonably good general education. True, the proper teaching of the natural sciences should occupy an important place in the general education of everyone, no matter what the subsequent field of activity may be. On the other hand undue harm may result from the psychological trauma attendant upon failure to gain admission to a medical school.

Another experiment is being conducted which may prove to be even more far reaching in its consequences than those already mentioned. The Army and Navy programs entirely eliminate the economic requirement

for the study of medicine. This irrelevant qualification—the ability to pay for college and professional training—has always been a limiting factor in the selection of students. Relatively few applicants to medical schools state that they will need financial assistance at the time of application, yet every dean knows that many students require such assistance after entering the medical school. Furthermore an unknown number of qualified and perhaps superior individuals never reach the stage of applying for admission to a medical school. They have never been able to start college or even finish high school for economic reasons. The theory that everyone intellectually qualified for higher education has a chance to obtain it in state or municipal colleges with low tuition rates or through loan and scholarship funds is only a theory without convincing supporting evidence.

Under the Army and Navy programs ability to pay for an education has nothing to do with those to be educated. A serious study should be made of this obvious but revolutionary principle to determine whether an entirely new source of highly qualified students is being tapped. It has been the experience of several medical school deans' selection committees that a large proportion of men being screened for assignment to medical school would be unable to attend were it necessary for them to provide their own funds. Everyone knows that some of our best students have earned much of their way, especially at the premedical level. This is to be commended and doubtless has permitted many with limited financial resources to obtain an education. However, it is questionable whether this is not a waste of time and energy. Would not the same effort devoted to more intensive, scholarly pursuits on the part of the superior student in question return greater dividends to the student and to society than laboring in a factory or mill while carrying the college work.

There are certain features of some of the military educational programs which we may at once dismiss as undesirable. The Army program allows for no selection of a specific school by the student assigned to medicine and permits no selection of specific students by a given school. This plan may be justifiable administratively but is educationally indefensible. The standardization of the premedical curriculum found in the military programs may again be desirable for administrative reasons but can find little educational justification. At the premedical level also schools differ in many other ways than in excellence of instruction, and schools equipped to emphasize one or another of the fields in premedical education should be free to do so, exploiting local resources to the fullest extent.

II. Integration of the Training in Premedicine and Medicine

It may be convenient to delimit chronological or academic periods in the training of a doctor and refer to the premedical period, the preclinical years, the clinical years and the internship. If these divisions are more than convenient concepts and actually describe successive and segregated stages of education, they are highly undesirable. Fortunately, the lines of demarcation are gradually being erased at some points. The transition between the clinical training in the junior and the senior year of the medical student and the internship is no longer as marked as it has been. In his clinical training the

medical student is responsible for patients. He takes histories, examines the patients and performs the laboratory and other tests much as he would later do as an intern. He must report his case to the attending physicians and is responsible for following the progress of the case. A patient assigned to him is as truly his patient as if he were a practicing physician, except that he is carefully supervised and his case load is not as great as it is during the internship or in practice. Some selected and superior senior students may even serve internships temporarily in medical school hospitals with considerable profit.

The line of demarcation between the preclinical and the clinical years is also no longer as sharply drawn as formerly. In years past a student pursued laboratory courses in his first two years of medicine and worked in hospitals or clinics or attended ward rounds in his last two years of medical school, and there was relatively little integration of the two phases of his training. At the present time a great deal of clinical material is being introduced into the first two years of the medical course. In aim and spirit this must be done, not to make clinicians of students prematurely, but to strengthen and vitalize the training in premedical subjects. Presentation of a case of infantile paralysis in an anatomy course need not emphasize the nature of infantile paralysis as a disease or include therapeutic procedures. The case can be entirely an anatomical study in which the student is shown the action of certain muscle groups which he is dissecting in the laboratory by demonstrating which movements are abolished or weakened when given muscle groups are paralyzed. Similarly in physiology the introduction of electrocardiographic material need not seek to make the student adept in the diagnosis of cardiac abnormalities. Such material can be invaluable in teaching the student the normal physiology of the heart and the action of the cardiac pacemakers and conducting systems.

There is also an increasing tendency toward the introduction of more basic science material into the clinical years. Free time for review and advanced studies in the basic sciences is being provided during the later stages of the medical training, and instructors in basic science fields are contributing to the conferences held for juniors and seniors dealing with teaching cases in the hospitals. This tendency to view the medical curriculum as a four-year continuum instead of as two separate units has been one important factor in the present tendency for schools of basic medical sciences to expand into full four-year medical schools. There are other factors involved in this development, but the recognition of the inadequacy of basic science instruction in the absence of any clinical contacts is one of the major influences. Two of the schools of basic medical sciences whose students formerly had to transfer to four-year schools for the junior and senior work have now expanded to four-year medical schools and two others are well on their way toward completion of the arrangements for such a change. Nearly all of the ten schools of basic medical sciences in the United States are exploring all possibilities in connection with similar expansions.

These developments in medical education suggest the desirability of a similar less marked transition from the premedical to the medical. Perhaps this will be more difficult to achieve since it will probably remain true for a long time that very many

medical students will take their premedical training at schools and universities having no medical school. However, a measure of change in the desired direction can be effected through premedical instructors familiarizing themselves to a greater extent than they have in the past with the basic medical science curriculum.

The instructor in physics who is alive to the important electrical changes that occur in active tissues and who knows something about the electrical nature of the nerve impulse can give material in electricity which will more effectively correlate that premedical subject matter with the medical work to follow. There is no intention that a course in physics or in any other premedical subject should be considered merely a tool course which will provide the student with information technics and procedures which he may later use in his medical studies. Physics should remain a scientific experience for the student. However, the electrical changes which occur in the beating heart and which make the heart a true battery with shifting positive and negative poles are as truly physical phenomena as those occurring in a battery. Similarly, in chemistry, such phenomena as osmosis and filtration can as well be related to living systems as non-living systems. At many points similar adjustments could be made which would in nowise debase the natural sciences but would correlate them more closely with biological phenomena and would add much in the way of student interest, even on the part of such students as may not be aiming at the subsequent study of medicine.

It is doubtful whether it is desirable to present special courses in premedical sciences for premedical students segregated from students with other ultimate educational aims. The biological aspects of chemistry and physics are as suitable in many instances for the teaching of these sciences to any student as are examples from engineering or industry.

There is room not only for a better integration of this kind, bridging successive stages in a student's education, but also for far more integration of related material which a student is taking at a given time. I have participated in the presentation of biology to college freshmen and sophomores in a collaborative enterprise in which lectures, discussions and laboratory exercises are given by twenty men from ten different university and medical school departments. The departmental affiliation and special interests of each instructor are subordinate to the subject matter of the year's course. Constant discussion and criticism of each other by participants in the course have led to the presentation of biology at this level which is far more economical and effective than is possible without such close collaboration.

The success of such plans in college teaching is stimulating medical educators to think along similar lines in which the anatomist, the physiologist and the pathologist do not give separate courses in their respective fields but collaborate in presenting an integrated picture of the body in health and disease in which accidental repetition is eliminated and planned repetition incorporated when required. For example, the joint presentation of the nervous system might employ an interdepartmental syllabus of topics, readings, references and laboratory instructions covering the gross and microscopic structure, the normal physiology and the derangements of that system

with the sequence of daily topics being determined by an interdepartmental committee of instructors.

III. BREADTH OF TRAINING

Since doctors have a larger responsibility in society than the immediate care of their patients, it is necessary that the premedical student obtain a broad, general education. It is as unsound to limit premedical training or sharply restrict it to the laboratory sciences as it is to permit a non-science student to complete college without working in the laboratory sciences. Experience in the humanities and the social sciences should supplement premedical scientific training just as work in the physical and biological sciences should be included in the general education of any student.

It is becoming increasingly evident that the doctor may not isolate himself from the broader affairs of mankind and live a narrow, professional life. The doctor increasingly realizes that he must have an understanding of sociology, politics and economics. Problems relating to the equitable distribution of doctors and the provision of adequate medical care and hospital facilities in all parts of the country including rural communities are as important to the doctor as those relating more specifically to illness in a given patient. The doctor should be equipped through education and habits of thought to deal with such problems as objectively as he deals with scientific questions which confront him. Such terms as prepayment plans, costs of medical care, hospital insurance, compulsory medical insurance, group practice and many others are terms as vital to doctors, medical students and premedical students as the terms dealt with in the fields of science. Even in their premedical studies, students should become acquainted with the many experimental plans for medical care now in operation under the auspices of railroads, industry, insurance companies, hospitals, clinics and county and state medical societies. We are graduating our students with equipment to practice good medicine but without adequate knowledge and understanding to cope with the problems of relating that practice to new social conditions in a rapidly changing world.

When the student arrives in medical school and begins his basic science instruction it is very common, if not universally true, for the biochemist to state that the student's training in chemistry was inadequate. The physiologist states that the student knows no physics and the anatomist that he is innocent of all knowledge of biology. This may be related not only to the kind of training the student has obtained in his premedical studies but equally well to the kind of training the medical school instructor imposes upon the student at that later time. The chemistry instructor crams his course with as much factual material as he possibly can within the time limits and if possible obtains more time to stuff with further irrelevant detail. This the student struggles to retain until examination time. He manages to keep but little of it by the time he studies biochemistry. The biochemist expects him to have retained everything he learned in chemistry and proceeds to repeat the previous chemistry experience by again capturing as many hours of the curriculum as possible and filling them with the maximum of material. Left to himself the instructor tends to over-emphasize the role of his field in the total picture and similarly has an exaggerated opinion of the importance of all the details within

his field. One of the most salutary influences I have ever observed in correcting this very general educational evil is the collaborative presentation of courses in which the instructor must justify to critical colleagues in other fields the inclusion of the material of his course in the curriculum. This does not mean that the anatomist will tell the biochemist what to teach or that the physicist will be the judge of what is to be taught in biology. It does mean that an earnest discussion of the curriculum content by several men will inevitably lead to each man evaluating far more carefully not only the subject matter of his course but also the manner in which it is presented.

Too often stress is laid on factual material with too little emphasis upon general principles and habits of thought. Fully as important as the facts of sciences is the principle that "facts" do not necessarily continue to be true but are temporary generalizations based upon limited knowledge. Facts must be constantly modified as our knowledge increases. No matter how well versed a student is in the current facts of a given science, unless all his thinking is colored with this viewpoint he is not well trained in the science. This atmosphere in which nothing is permanently settled and in which learning must be a continual process of revision is not nearly as comfortable as that in which a fact is learned and that is the end of the matter.

We have no greater obligation than that of guiding the student into scientific habits of thought. There is no better way of effecting this in the case of at least the superior student than to have the student himself engage in some investigation involving laboratory procedures. In the physiology department at the University of Chicago, in which undergraduate students as well as medical students and graduate students may work, it was possible for a student to take his Bachelor's degree with his major emphasis in the field of physiology. Every such candidate for the degree was required to devote approximately one-third of his time for a six months' period to laboratory investigation. In most instances this involved the student assisting a staff member in some research problem under way by that instructor. In the case of many students the assistance was minor. Those students who showed themselves capable of greater responsibilities were assigned larger places in research teams and a few superior students were able themselves to carry out minor problems in laboratory investigation. Rarely were very significant contributions made by the student to the major research problem involved, but the educational returns to the student were greater than could be obtained in learning more factual material from textbooks, lectures or routine laboratory work in the special courses in physiology. Such work gives the student first-hand knowledge of how science grows and the source of the material which he studies in his other courses in science. He cannot obtain this feel toward science entirely by reading about experiments done by others. Except by participating in an experimental attack upon an unsolved problem, it is not possible to appreciate the great labor and patience and persistence which is necessary in the solution of even a very minor problem in the field of science.

It goes without saying that this direct instruction in the scientific method and in research cannot be given by instructors who themselves are not stimulated to seek answers to some questions, however minor

they may be, that remain unanswered in the great realm of the unknown in science. The student who goes through his premedical and medical courses learning all the material at his disposal without becoming especially interested in one of the many unknowns he encounters in his studies has missed something fundamental to his education and vital to his later practice of medicine. The instructor who teaches what is known, however excellently, is remiss as a teacher unless he arouses an impelling curiosity in his students regarding the unknown. This he can scarcely do unless he himself has been sufficiently stimulated to attempt to solve some problem at which he has worked earnestly during some of the time remaining after the responsibilities of the classroom, the laboratory or the clinic have been met.

SOCIAL SCIENCE

PROCESS AND TRANSITION IN SOUTHERN ILLINOIS RURAL SOCIETY*

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I—INTRODUCTION

That the history of rural America can be interpreted as the change from homogeneous, self-sufficient communities to heterogeneous interrelated "rurban" areas is now a fairly common view in rural sociology. Less frequent, however, is the utilization of certain aspects of this historical change as documentation for a general theory of social and culture change. Adherents of this theoretical position view human society as expressed within two major ideal types or tendencies of social action, culture, and mentality. These "types" have been variously termed *Gemeinschaft-Gesellschaft*, sacred-secular, folk-urban,[1] and many others. It is important to remember that these terms refer not to actual, empirical societies, but to *ideal types* of society, used both as polar standards to define a range of variability within which existing social units may lie, and also to develop hypotheses about the interrelations of social and cultural forms within the ideal-type categories. The advantages of using this theoretical framework lie in the fact that it provides a common terminology and a common set of basic problems. Thus communities as diverse as a Kentucky mountain community, a New Mexico desert town, a West African native village, and an "acculturated" American Indian society can be analyzed from the standpoint of various problems developed from the theoretical sacred-secular change.

We do not imply, of course, that the American rural change is identical with all changed folk cultures throughout the world. Although the same fundamental questions can be asked for all, the specific research problems naturally vary. In rural American culture, the particularly crucial problem is concerned with the varying types of "urbanization" of the countryside. While it is recognized that by and large urbanization follows similar broad patterns everywhere, its operation in each region, area, and community may significantly vary - significantly from the standpoint of interpreting the causal background of socio-cultural change. Furthermore, we are interested in constructing major types of "urbanization", which can be used

* This paper is based on the results of several field studies in two counties bordering the Ohio River in southern Illinois. Mr. Herbert Passin initiated this research and directed it in the field. Sponsorship of the studies lay with the University of Chicago, Social Science Research Council, and U. S. Dept. of Agriculture, Extension Division. All conclusions are made on the basis of the field work done in 1939-1941. The war will have introduced important modifications in the general culture-change situation.

[1] *Vide* R. Redfield, *The Folk Culture of Yucatan*, University of Chicago Press, 1941.

for our theoretical problems in the sacred-secular context.

II.—CULTURE AREAS

The human ecology of the counties bordering the Ohio River in southern Illinois includes exceedingly diverse elements, varying from shanty-boat dwellers on the river to German-American farmers in the hills. It is possible to distinguish two kinds of cultural groupings (excluding the larger towns) in this area: 1. Small communities with a relatively high degree of correlation between legally-defined boundaries. The crossroads village of Stringtown[2] is typical. 2. "Neighborhood" areas of variable extent, with patterns of intercommunication and ecological determinants[3] giving them cultural if not legal unity. A riverbottoms area along the Ohio is such a neighborhood; even though it is populated by unrelated mobile families, who must depend on the towns for all services (save for a school), the area has a distinct pattern of social interaction which separates it clearly from other neighborhoods.

In the past, the region possessed two major cultural patterns, the German and Old American. The subareas in the second category possessed a uniform culture and socio-economic background: similar agricultural techniques, a general pattern of collective action, mutual aid, strong church and family authority, self-subsistence. Moreover, the social structure of each of the Old American areas was essentially similar. In the past, therefore, the basis for sub-areal division as far as the Old American areas are concerned, was primarily geographical; whereas at the present, the areal differentiation is a matter of varying cultures and social structures.

The broad view of social change in this region consists in recognizing the transition from a relatively homogeneous culture and economy to one which still possesses regional unity, but which contains within its borders communities and subareas with specialized cultures, societies, and patterns of social change.

The region studied comprises about one-half of each of two counties, the socio-cultural area thus not conforming to the political boundaries save only in certain formal aspects. This region constitutes on a large scale a relatively unified "community" or culture area. Such unity can be seen in terms of the following: (a) Residents of the region recognize it as "our country"; their definition of the outside world includes everything beyond the borders of this region. (b) The region is *relatively* self-sufficient, containing major facilities for economic and personal service. (c) Within the confines of the region, the incidence of social interaction is higher than it is with any part of the region and the outside areas.[4]

Finally, the region as a socio-cultural area can be broadly characterized by certain types of socio-economic organization and cultural forms. We may summarize these as follows.

(1) Agriculture is based upon a division between the upland and the river-bottoms. The latter constitutes a virtually inexhaustible source of rich soil, while the hills soil is becoming extremely infertile. Thus a major portion of farm operators in

[2] *Vide* H. Passin, "Culture Change in Southern Illinois", *Rural Sociology*, Vol. 7, No. 3, 1942.
[3] *Cf.* E. T. Hiller, "Houseboard & River-Bottoms People", *Ill. Studies in the Social Sciences*, XXIV, No. 1, 1939.
[4] With the usual exceptions, of course, in the form of individual families who may be related to families in adjoining regions and towns. But these are in the minority.

the hills must rent fields in the bottoms to make sufficient money. This brings hill people into interaction with bottoms-dwellers, and frequently results in hills families moving into the bottoms. In the course of time, this dependence of the hills on the bottoms has become increasingly important.

(2) Other hills areas, particularly the German-American farmers, do not depend on bottomland for cash crops, but participate in mutual-aid neighborhoods with other hills people who do depend on the bottoms, and also trade in the same villages and towns as do bottoms and other hills people.

These and other modes of interaction within this region have led to broad and general similarities in the culture pattern, such as agricultural techniques and equipment, religious beliefs, family types, and so on.

In addition to the relative unity of this regional culture at the contemporary period, it is possible to discover certain patterns of change which characterize the whole. Although each sub-culture in the region has felt the effects of urbanization and secularization differently, in the regional view these differences can be ignored for wide-scale descriptive purposes. It is possible to describe the region as being relatively heterogeneous, urbanized, socially-differentiated, and dependent upon services extended by the larger urban centers of the general region. Formerly a "backwoods" district in southern Illinois, typified by independent, relatively isolated subsistence farms, the area is now economically tied to the wider cash crop agricultural market. Inequalities in land holdings and soil efficiency prevail, with correlated social class and status differences.

Our problems, therefore, are set by the following conditions. On the one hand we can recognize a region which can be generally described as uniformly urbanized and socio-economically changed, and on the other we can distinguish sub-cultural units within this region which have their own distinctive patterns of change and degree of urbanization. Because of individual cultural and social differences the units have responded differently to the regional processes of change; a proper understanding of these processes must include the recognition that the regional picture is not a simple sum of the parts, but a complex expression of social interaction and historical relations.

Obviously we cannot ask all the questions relevant to such a view, since the problems are too comprehensive in scope. We shall merely describe briefly the type of change in each of the important sub-cultures of the region, and attempt to point out some of the more important conclusions to be drawn.

III—CULTURAL CHANGES

Culture Change in Stringtown.—Stringtown, as one of the two small villages in the region, is a "community" with more or less formal legal and social definitions. It has been a permanent settlement for a group of families for 90 years, and has been a trading center for people of other sub-areas almost as long. The relative unity of the social group and the persistence within it of family lives and cultural forms have determined in many respects the character of urbanization and heterogenization of the present time.

The key factor in Stringtown culture change was the growth of moonshining during the Prohibition era. Previous to this time, the community had resisted economic and cultural

secular influences with greater success than some other sub-areas, because of a series of factors all more or less traceable to the distinct social and economic unity of the village.

The results of liquor-making can be summarized:

1) Removal of a large proportion of Stringtown families from an agricultural economy.

2) Sudden increase in available cash, and associated random, uncontrolled spending on "urban luxuries".

3) Intensive use of automobiles.

4) Familial ruptures over the question of morality of liquor-making, and subsequent breakdown of family solidarity and authority. Growth of immorality of all kinds.

5) Breakdown of the authoritarian moral guidance of the church.

The list could be indefinitely extended. The essential point is that moonshining embodied all the essential secular tendencies in the economic, social and cultural spheres leading toward social differentiation and cultural heterogeneity—and all these tendencies became operative in the short space of one decade.

The effects of this sudden impact of secularism were as follows:

1) Local social controls were profoundly disturbed on the familial and community levels. "The community as a whole is not a well-integrated unit commanding the loyalties of the villagers".[5]

2) Removal of a large majority of villagers from a farming economy introduced acute economic insecurity and caused the growth of a class of landless families.

3) This group constitutes a "lower-class" element, as contrasted to the "upper class" group of farmers. The landless group is divided into various marginal occupations: WPA, relief, small sharecropping and itinerant labor. Status lines are not clearly fixed within and between these occupations.

4) A widening division between the young people, who grew up in the intensely urban-oriented 1920's, and the older inhabitants, who still cling to the older values and practices, wherever possible. Status distinctions, though indistinct, tend to follow this age-differential. An older, traditionally-oriented person will participate within a different status hierarchy than will a younger, urbanized individual. The relation of such alignments to the socio-economic two-class division is as yet in a fluid condition.

5) Whereas in the "old days" Stringtown was virtually self-sufficient within its ecological area, having all the services (stores, etc.) required for the period, today its people are increasingly dependent on the services of the larger towns and are unable to find resources in the old community which satisfy and support them.

Social Differentiation in the Bottoms.—In contrast to Stringtown, where a stable well-knit social structure resisted change more or less successfully until a sudden powerful impact destroyed the homogeneity once and for all, the Bottoms began its transition at an early period and gradually developed a differentiated mobile social system which is adapted to the problems and tensions of a changing culture.

The bottomland area south and southeast of Stringtown was the last area of the total region to be settled by white farmers, since the necessity of clearing heavy vegetation and the

[5] Passin, *op. cit.*, pg. 314.

fear of floods defeated earlier attempts. The soil was found to be immensely fertile and settlement was rapid. Although small subsistence farms were the rule in the beginning, most (and eventually all) of the land soon came under the ownership of a few landlords, who rented their property for cash. In a relatively short time this system gave way to a tenancy-sharecropping arrangement, which exists at the present time.

As the land itself fell into fewer and fewer hands, the introduction of agricultural machinery permitted fewer and fewer operators to farm a given tract. Thus most of the small renters and other Bottoms inhabitants gradually became a mobile farm labor group, or became part-time fishermen. Shantyboat people from the river, no longer able to make a living from fishing, camped semi-permanently on the riverbank. In recent times, the introduction of WPA created an additional economic grouping.

These long-standing socio-economic groups—tenant, sharecropper, farm laborer-riverbank squatter, fisherman—have in the course of time developed into a ranked status system, with the super- to subordinate order roughly as above. WPA has been distributed between the sharecropper-farm laborer groups. Mobility of families and economic insecurity have prevented a "settled" society, *a la* Stringtown; nevertheless Bottoms dwellers possess considerable solidarity and a consciousness of the great difference between their culture and the others of the region. Such attitudes also function as rationalization for their economic difficulties and as it often happens, their failure as farmers in other areas.

The more mobile Bottoms people, particularly the riverbank-farm laborer element, have generally had considerable contact with the larger regional towns, either as laborers or in weekly trips for purchasing food. Such contacts have introduced a wide variety of random, dissociated urban traits: comic books, wieners, "pop", and the like. The more far-reaching effects of such contacts and mobility can be seen in the disoriented, secularized attitudes and behavior of these Bottoms residents.

The important facts to remember in the case of the Bottoms are:

1) Economic changes, operating through land-tenure, were operative in the Bottoms long before they were apparent in other sub-areas, even though the Bottoms were settled last.

2) Familial mobility and insecurity have prevented the growth of an inter-related, integrated "community". Nevertheless solidarity exists.

3) Adjustment of drastic socio-economic change to the values of the regional equalitarian, individualist culture has been a ranked status system, which is characterized by aspiration toward the tenant-farm level. Such a system permits the individual to believe he can "work himself up" from riverbank to tenancy (actually he cannot for many reasons); thus it functions as a rationalization of extreme social differentiation. The Bottoms, by a process of long adjustment, has perhaps accomodated to change more efficiently than Stringtown, where everything, so to speak, went at once.

Culture Change in the Hills.[6]—

[6] For materials on the Hills we are particularly indebted to Lt. H. L. Smith, U.S.A., who specialized in this area while in the field.

The hills north of the Bottoms have three principal sub-areas.[7]

1) *The Northeast Hills* is an area closely related to the eastern Bottoms, since most of the sharecroppers and tenants of the latter come from the former. This sub-area is characterized by small subsistence farms located on hilly loess soil, badly eroded and never properly farmed. Most of these farms are marginal or sub-marginal, on relief or FSA. Many have been abandoned. The principal pattern of change in this subarea has been as follows:

Since the hilly, rugged northeastern subarea was least desirable in the eyes of the incoming Southern settlers, it was occupied by only the most mobile and least educated families. Extremely exploitative farming techniques permitted an adequate living for many years, but eventually erosion and soil exhaustion took their toll. The various farm relief devices of the present period have indirectly served to convert most of these former self-supporting small farmers into a rural proletariat living on a strictly cash basis, but who still reside on the crumbling properties. Most of the farms are no longer adequate for subsistence, let alone cash crops.

2) The rolling, but fertile *Upper Hills* is the most "successful" of all the Old American regional areas in that it has been affected least by change from an economic standpoint, and has maintained its traditional culture to a large extent. The "best" families settled here, practiced reasonably careful agriculture, and established large families. Geographical isolation rendered contact with the towns and cities infrequent.

At the present, isolation is still important, although the children attend high school in a regional large town, and are inclined to leave the old homesteads in increasing (though still small) numbers. The war has accentuated this trend, of course. Crops are still good, and permit a secure living, although not as abundant as in the past. The culture as a whole has not broken up: young and old go to church; family and religious authority is strong; many old customs, such as the "shivaree", persist here and in no other subarea. The Upper Hills was able to take over a cash-crop agricultural system, adapting itself to the changed economic relations but preserving the essential features of the old folk culture. The Upper Hills and the Bottoms, despite profound cultural and economic content differences, have some processual similarity in that change is occurring (in the Hills) gradually and is accomodated by a realignment in the social structure. A ranked status system is developing in the Hills, based largely on traditional vs. urban oriented families, while in the Bottoms the status heirarchy was principally a matter of socio-economic differentiation. The structural adjustments are similar but the content varies. A Stringtown-type dual status system is apparent, also, though very much undeveloped, since the old culture is still powerful.

3) The *German Hills* is spacially interspersed and socially interactive with the Upper Hills. This broad area includes the finest farms of the region and by and large, the most stable, successful families—superseding in these respects any of the Old American areas. These German farmers are of both Pennsylvania Dutch and Old Country descent, and began entering the region as early as 1858. They have retained to an extraordinarily great extent the frugal, care-

[7] A fourth, the Lower Hills, will for this brief paper be considered as an extension of Stringtown; in a sense, the most stable, landed element.

ful and efficient agricultural economy of their places of origin.

Culture change in the German Hills has proceeded in two directions: (a) Economic change from a largely self-subsistence economy to a cash crop basis. In this regard, the German Hills stands about equal to the Upper Hills in respect to amount of influence such a change has had. It is not as great as in the Bottoms or Stringtown. (b) The alteration of the old German culture towards the Old American (Upper Hills) pattern.

The latter change has been gradual and subject to resistance on the part of the Germans, but the process has gone on. The language is now spoken by only a few oldest inhabitants; the characteristic old German foods—sausages, cheeses, *et. al.*—are now of no great importance in the whole diet. The acculturation process is accompanied by noticeable tension and some anxiety in the form of an attempt by German farmers (and their wives) to conceal from an observer any prominent vestiges of the old culture.[8] A status system (not clear-cut) has been developing along the familiar old-young lines, differing from Stringtown in that the explicit age factor is not as pronounced, the underlying American-oriented — German-oriented hiatus being more apparent. As time goes on, however, the youthful individuals will tend more and more to represent the American-oriented group.

In both the Upper and German Hills there is a developing relationship with residents of one of the larger towns of the region, *via* sons' and daughters' marriages with townspeople. This factor is introducing and integrating many urban tendencies particularly in the area of food habits, child raising, and reading. Such changes should be contrasted to the superficial, uncoordinated, urban-luxury desires of many of the mobile, acculturated, low status people in the Bottoms, and former moonshiners in Stringtown.

The Negro Communities. — Two Negro neighborhoods lie in the area on the northern margin of the Bottoms. One is as old as any of the Old American subareas, being populated primarily by families forced out of the Bottoms by whites many years ago. The people of this older area are the most traditionally-oriented, possessing much of the old Negro culture: superstition, magic, midwivery, etc. The newer neighborhood is the most urbanized of the two, and the most economically debased. Many of the older neighborhood's families have enough land to raise gardens; very few of the younger area's families have such land. WPA and relief literally kept Negro families alive (particularly in the newer area) during the period of field study.

Culture change in these Negro neighborhoods has consisted of the almost complete loss of land and progressive breakdown of the old self-subsistence structure until it no longer exists. This is more extreme than in any of the white areas. Along with this change went the breakdown of much of the traditional culture and extended family system. Since, however, the regional status of the Negroes relegates them to a caste-like position, the internal results of change have been quite different from the white areas. Such cultural elements as the church have been strengthened and intensified in the face of disintegration, as an attempt to preserve the sense of au-

[8] The war is doubtless the major factor in this attitude. It is a common phenomenon in German-American groups in the Midwest, and may be also in other parts of the country.

tonomy and distinctness which the Negroes still possess, and also to provide a central rallying-point for people and culture. There is a general analogy between this phenomenon and "revivalism" in American Indian cultures.

A status system is also apparent, although not clear-cut, and apparently old: The descendants of the old landowning Negro families are superordinate; the younger, disorganized families, generally on relief, are subordinate. The WPA segment may have been (in 1941) showing tendencies to merge into the *regional* WPA low-status rank, along with the whites.

IV.—SUMMARY

We may summarize the materials on culture change in these various socio-cultural areas of the region.

First, it is evident that each of the areas briefly discussed has experienced a change from a relatively independent, self-subsistent, homogeneous society-culture to a relatively dependent, differentiated type. Such changes in the economic, social and cultural spheres are to be attributed to the large-scale influence of the increasingly centralized, pecuniary, complex American economic system, and the accompanying social readjustments. Regionally these sub-cultures are no longer independent units, but relatively specialized, inter-dependent areas within a wider "town-country" network of interrelations.

On the one hand, homogeneity within the sub-cultures has given way to heterogeneity in varying degrees; on the other, the region has become more inter-dependent from an economic standpoint, since Hills people depend on the Bottoms for cash crops, and services are now supplied by stores in nearby towns. Thus in the cultural and social structural context, the region is less well organized than in the past; from the economic (and to a certain degree, the socio-economic) standpoint, the region is more highly organized.[9] This is more than a simple-to-complex, folk-to-urban change, but the development of a new type of socio-economic structure which might be called *transitional*, since it more or less successfully places the folk and the urban in some form of concordant framework.

In each of the areas examined, this transitional structure has taken different forms, according to the specific culture-historical background and socio-economic conditions. In Stringtown, the recent impact of change has been scarcely accomodated, but the development of a dual status system based on the traditional-urban orientation division, and stratified by socio-economic class, is now in process. In the Bottoms, the traditional-urban hiatus is lacking, since *all* Bottoms dwellers are relatively mobile, acculturated individuals. But socio-economic groupings have been converted into a systematic rank-order status system, which adapts the changed conditions to the generally accepted individualistic-competitive values of the older pattern. Among the Negroes, disorganization is partially controlled by an intensification of certain institutional features, particularly the church and religion, which is a result of the added complication of caste-status.[10]

In the Northeast Hills, it would appear that the problem is unre-

[9] It should be remembered, of course, that each sub-culture should be regarded as a problem in itself. In certain contexts, individual sub-cultures might not bear out this generalization. But seen as a whole, each sub-area fits into this kind of regional process.

[10] *Cf.* E. C. Hughes, *French Canada in Transition*, Univ. of Chicago Press, 1943, for an analysis of the relativity of status in terms of ethnic (French & English) divisions.

solved. The culture and economy is broken; residents are migrating.[11] In the Upper Hills, the older culture is powerful enough to command respect and authority, although movement of the children away from the area is occurring. A Stringtown-type dual status system is arising. In the German Hills, adjustment takes place as the German families approach an acculturated norm in which the culture is composite Old American-German, and social and economic interaction occurs with Upper Hills farmers. In the province of direct urban influence, the firm integration of urbanisms *via* relatives in the Hills must be contrasted with the random urbanisms of the Bottoms and Stringtown.

From these brief conclusions, it would appear that the concept of "urbanization" is indeed a complex one, and must be explored both in the broad processual sense and in specific change-situations. For different problems, different views of the concept are necessary. If interested in prediction of culture change, a general typology of transitional societies and processes must be erected. If interested in practical endeavors, such as modification of food habits or farming techniques, we must distinguish carefully between socio-economic forces operating on a regional basis, and those (plus cultural differences) in operation on the sub-areal level.

Thus if we wished to alter food habits for the region, we could first consult materials concerning regional problems of supply, general sales trends, and the like. But each of the sub-areas would have to be considered in terms of the distinctive integration of food habits in the varying conditions of culture change,[12] such as status and prestige in the Bottoms, acculturation and prestige in the Hills, urban tastes in Stringtown, and so on. The consideration of such factors would have to be integrated within a regional modificatory program based on such factors as economic and transportation requirements.

Underlying such considerations are more fundamental theoretical questions regarding the delimitation of areas of social interaction, social status, and particularly the contribution of a "sub-culture" to the regional culture area of which it is a part. Questions in these fields can be answered only by co-ordinated research both in the field and on available published studies. The important requirement is the systematic formulation of problems.

[11] This conclusion is tentative and subject to revision. If FSA continues to function, the situation may persist indefinitely.

[12] *Vide*, J. W. Bennett, H. L. Smith, H. Passin, "Food and Culture in Southern Illinois", *American Sociological Review*, Vol. VII, No. 5, 1942.

ZOOLOGY

RATE OF ESCAPE OF FISHES FROM HOOPNETS*

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DESIGN OF THE HOOPNET

The traps used in the present experiment are called barrel nets, wing nets and fyke nets, as well as hoopnets. The nets of this type used by commercial fishermen vary in design with respect to number of chambers, size of mesh, size and shape of the funnels, and length of wings. The so-called buffalo net, which is similar except that wings are absent, is especially designed for use in strong current. The general design of the net described below is fairly typical of the wing type nets used on the Illinois River and at least on some parts of the Mississippi. These nets are nearly always made with two compartments and with wings under 10 feet long.

Figure 1 shows five freshly tarred nets loosely stretched for drying. The wings are doubled back over the hoops and are not clearly shown. Four other nets with poles attached are shown stacked in the upper right hand corner of this figure. The cylindrical part of the net is made of a series of metal or wooden hoops covered with netting, the mesh of which differs in size in accordance with various legal specifications and preferences of the fishermen. The wings are rectangular pieces of netting, one on either side of the front of the net and attached in such a way as to guide the fish toward the entrance funnel. Midway from front to back a second funnel divides the net into two compartments. The funnel openings are midway between top, bottom and sides. The opening of the front funnel is ordinarily considerably larger than that of the second. A fish entering the front compartment usually moves about until it either escapes from the net or passes through the second funnel into the rear compartment, from which chances of escape are lessened because of the smaller diameter of the back funnel opening and because the inner funnel is camouflaged by the finger-throat. See drawing. Finger-throats were used on the rear funnel of all the experimental nets. The commercial nets, however, are sometimes built with finger-throats on both funnels, but at other times the fingers are omitted from one or both funnels.

Three stout wooden poles, one at the end of each wing and the third at the end of the drawstring, which closes the back compartment, are pushed into the river or lake bottom to hold the nets in the "set" position. A separate piece of netting, mounted on poles, called a lead, has the function of guiding the fish to

* For his critical reading of the manuscript I am especially indebted to Dr. David H. Thompson.

FIG. 1.—Freshly tarred hoopnets on a drying lot. The wings on the nets in the foreground are doubled back over the cylindrical part of the nets and are, therefore, not clearly shown.

the space between the wings. Leads are not often used in connection with nets set where there is strong current.

The nets used in the experiments had approximately the following dimensions. The cylindrical portion of the nets used was 10 to 12 feet long, with wings about 8 feet long, making the total length about 20 feet. The net diameters were of 2 sizes, 3½ feet and 4½ feet and were fished in water of these respective depths. The wings, front funnel and outside wall of the front compartment were of 1½ inch mesh bar measure. The second funnel and rear compartment were of 1 inch mesh bar measure. All nets had square or round entrance funnels except net No. 7 in the 1944 tests at Lake Glendale, which had vertical slots for entrances; these slots were the same height as the net itself. The average diameter for the front funnel opening was approximately 10 inches and for the back funnel 6 inches. Leads 60 feet long were used with all nets.

DESCRIPTION OF THE EXPERIMENTS

The experiments were conducted at Maple Lake, Cook County, in the fall of 1941 and at Lake Glendale, Pope County, in the spring of 1942 and 1944. Mr. Daniel Avery, field assistant with the Survey, was an enthusiastic participant. Shortly before the beginning of the experiments, it was learned that fish placed in the rear chamber of a net could make their exit by way of the funnel openings through which entrance to the net had originally been made. On one occasion largemouth bass and on another occasion warmouth bass had escaped when numbers of each had been stored in nets overnight.

The tests consisted of taking the fish caught in a given net, marking them with a metal tag or by cutting off part of a fin, and immediately replacing them in the same net in the rear or innermost of the two compartments. The nets were then reset and were not disturbed until a recount of the marked fish was made 1 or 2 days later. The fish were not credited with an escape unless absent from both compartments when the recounts were made. Escape necessitated an exit first through the rear funnel and finally through the front funnel.

The tests showed very conclusively that both the bluegill and the largemouth bass are adept at making escapes. Only a few individuals of other species were tested. The ability which some fish have of getting out of the net after capture has been recognized by Jacocks (1943). This ability is also recognized by some commercial fishermen, but generally the failure of the nets to capture certain species is attributed by the commercial fishermen to the alertness of the fish in avoiding the nets rather than in their ability to escape after original capture. The manner in which hoopnets are selective for certain species is strikingly shown by Schumacher and Eschmeyer (1943). A decided lack of correspondence in proportions of different species in hoopnet and anglers' catches has been shown by the writer (1942).

Species referred to in table 1 include the following:

Bluegill—Lepomis machrochirus machrochirus
Green Sunfish—Lepomis cyanellus
Pumpkinseed—Eupomotis gibbosus
Warmouth Bass—Chaenobryttus gulosus
Largemouth Bass—Huro salmoides
White Crappie—Pomoxis annularis
Black Crappie—Pomoxis nigro-maculatus
Black Bullhead—Ameiurus melas melas

EXPERIMENTAL RESULTS

The kinds and numbers of fish employed in the trials and the numbers of fish making escapes are shown in table 1. The number of escapes from individual nets ranged from none out of 6 bluegills kept in a net for 24 hours to 16 out of 16 bluegills (100 per cent) kept in a net for 50 hours. The results of the several trials may be summarized as follows:

One day trials at Maple Lake. Average time 23½ hours.
81 bluegills used: 26 or 32 per cent escaped.
3 white crappies used: 0 escaped.
2 warmouth bass used: 0 escaped.
1 pumpkinseed used: 0 escaped.

One day trials at Lake Glendale. Average time 23 hours.
44 bluegills used: 16, or 36 per cent, escaped.
16 largemouth bass used: 6 escaped.

Two day trials at Lake Glendale. Average time 51 hours.
36 bluegills used: 32, or 86 per cent, escaped.
5 largemouth bass used: 1 escaped.

It should be understood that the experiments were conducted with the hoopnets set in the usual way for catching fish. The actual numbers caught during these tests are shown in the right hand column of table 1. By clipped fins or metal tags the experimental fishes could be separated from those which were newly caught.

VALIDITY OF RESULTS

The validity of the experiments would, of course, depend on the conditions (1) that there were no broken meshes in the nets through which the fish could escape, and (2) that the experimental fish were not stolen from the nets. The nets were examined for holes both at the beginning and the end of each of the trials and no breaks were found. It is unlikely that any of the fish were stolen. While the nets remained unguarded at night, we are satisfied that we would have recognized a net that had been disturbed, especially since in both localities most of the residents are unaccustomed to hoopnet manipulation. Even if thieves had disturbed the nets and had tried to reset them, it is unlikely that the nets would have been left in good order.

The individual lengths of the fish used in the experiment at Maple Lake were not recorded. They were all of moderate size. At Glendale, the bluegills and bass were measured at the start of the experiments. The

TABLE 1.—DETAILS OF EXPERIMENTS TO FIND OUT HOW MANY FISH WOULD ESCAPE FROM AN ORDINARY TWO-COMPARTMENT HOOPNET WHEN FISH WERE MARKED AND PLACED IN THE REAR COMPARTMENT

Date	Net and fin marked	Period of experiment	Kinds of fish used	Number used in experiment	Number of escapes	Fish caught in the same net during the period of the experiment
			Maple Lake—1941			
Oct. 4	Net No. 6 Pelvic	22 hrs.	Bluegill	54	19*	26 Bluegills
			White crappie	3	0	4 White crappies
			Warmouth	2	0	1 Black crappie
			Pumpkinseed	1	0	1 Warmouth
						1 Black bullhead
Oct. 5	Net No. 6 Pelvic	25 hrs.	Bluegill	27	7**	24 Bluegills
						6 Black crappies
						1 White crappie
						1 Black bullhead
			Lake Glendale—1942			
March 12	Net No. 1 Right Pelvic	24 hrs.	Bluegill	6	0	99 Bluegills***
			Largemouth	2	0	1 Largemouth***
						1 Black bullhead***
	Same experiment continued	54 hrs.	Bluegill	6	no count	217 Bluegills
			Largemouth	2	1	11 Largemouth
						3 Black bullheads
						1 Green sunfish
March 12	Net No. 3 Left Pelvic	49 hrs.	Bluegill	8	5	29 Bluegills
			Largemouth	1	0	4 Largemouth
						5 Green sunfish
						1 Black bullhead
March 12	Net No. 5 Dorsal	50 hrs.	Bluegill	12	11	26 Bluegills
						2 Black bullheads
						1 Green sunfish
March 12	Net No. 7 Anal	50 hrs.	Bluegill	16	16	48 Bluegills
			Largemouth	2	0	8 Largemouth
March 14	Net No. 7 Anal	24 hrs.	Bluegill	38	16	20 Bluegills
						6 Largemouth
						1 Black bullhead
			Lake Glendale—1944			
March 27	Net No. 7 Metal Tag	24 hrs.	Largemouth	12	6	not observed
March 27	Net No. 8 Metal Tag	24 hrs.	Largemouth	2	0	not observed

* One more bluegill (not included among the 19) had succeeded in reaching the front compartment.
** Two more bluegills had reached the front compartment. Two of the experimental fish were dead in the rear compartment.
*** Counted and returned to net, but not marked. Included in the 54-hour set below.

bass ranged from 9.6 inches to 13.9 inches total length in the 1942 trials and from 8.2 inches to 19.0 inches in the 1944 trials. The bluegills ranged from 6.3 inches to 8.6 inches. The bluegills at Maple Lake were smaller, ranging from 4.5 inches to 7.0 inches. Since 1 inch mesh, bar measure, is fine enough to retain bluegills as small as 3.6 inches and largemouth bass as small as 6.5 inches, is is clear that the smallest sizes used in the experiments were too large to escape through the meshes.

Where several trials were started on the same day as at Lake Glendale (on March 12, 1942), the fish belonging to different experiments were marked by clipping a different fin except in 1944 when the bass were marked with metal tags. The practice of clipping different fins was followed in order that the fish could not escape from one experimental net into another without being recognized. There were no instances, however, of such mixing.

There was, of course, no way of recognizing a fish which might escape from a net and later return to the same net. Such occurrences probably were rare, but would result in the tests showing fewer escapes than actually occurred.

Controls to show the effect of fin clipping on the number of escapes were not used in connection with these experiments. The effect of fin clipping might be of two kinds. Fin clipping might interfere with swimming and hence tend to lessen the number of escapes. On the other hand, the operation might intensify the desire and the effort to escape. The latter effect, however, does not seem to be an especially likely one. Neither caudal nor pectoral fins, which are much used in swimming, were clipped.

THE EFFECT OF WATER TURBIDITY ON NUMBER OF ESCAPES

The escape trials at Maple Lake were run under quite different conditions of turbidity than those at Lake Glendale. At Maple Lake the (4 inch, white) Sechii disc disappeared at a depth of 29 inches while at Lake Glendale the disc could be seen to a depth of 13.5 inches on March 14, 1942; to a depth of 10 inches on March 15, 1942; and to a depth of 10.5 inches on March 27, 1944. The more turbid conditions found at Lake Glendale did not seem to have a noticeable effect on the number of escapes. This would be contrary to the expected result if the escapes are made with the aid of vision; that is, by the trapped fish seeing and purposely swimming through the funnel openings. It is quite possible, however, that a turbidity threshold might be found at which the number of escapes would be very much reduced.

It should be kept in mind that while the turbidity conditions were not the same in the two lakes, certain other conditions were also different, including sizes and ages of the fish used and temperature of the water. These factors, however, would not seem to have so much importance as turbidity differences.

THEORY OF HOW FISH ARE CAUGHT

Fish entering the trap do so by their own movements. Supposedly some are caught because the entrance hole happens to stand in the exact path of movement, while others are taken when they attempt to get past one of the wings which has interfered with forward movement. There is also the possibility that certain species, for example, members of the catfish family, are actually attracted by the enclosure, just as they are attracted by hollow logs and bank

holes. For certain other species the net might have the same attraction as brush or submerged tree tops. To some extent the fish within the net may decoy others. Also, a "sheep" reaction, in which one fish entering the net is followed in closely by others, may be important. Entrances and departures of fish in pairs has been observed by Mr. Robert Clark of Bath, Illinois. Some fishermen bait the nets, but this is not often done with the wing type hoopnet. Baits are almost never used in the hoopnet operations of the Illinois Natural History Survey.

THEORY OF FISH ESCAPE

A horizontal plane passed through the center of the hoopnet will show that the sides of the funnels and the sides of the net form a succession of hearts. The writer used to imagine that the heart-shape of the net chambers contributed to the success of the net in retaining captured fish. It was supposed that a trapped fish in trying to find its way out was kept swimming in circles. The writer also pictured the trapped fish as carrying on a more or less continuous and excited search for a route of escape and that its excitement contributed to failure to find that route. But this sort of behavior is not the kind described to me by Robert Clark and Jack Varnox, both of whom watched fish in hoopnets in the winter through clear ice at Bath, Illinois. According to these men, the fish which they watched showed not the least sign of excitement within the net; whether entering or escaping from the net, their movements were always leisurely. Clark has watched the entrance and escape of crappies, sunfish and bass, while Varnox has watched entrance and escape of bullheads. Clarence Pace of Liverpool, Illinois, has watched the behavior of carp (*Cyprinus carpio*) in the nets and found that they were much more sluggish in winter than in summer. In the summer he has seen carp enter a net and immediately turn around and go out without the slightest difficulty. In this connection we have noticed that fish brought from the wild to indoor aquaria seldom show any excitement as a result of the close confinement.

My colleague, Bruno von Limbach, suggests that fish captured in hoopnets ordinarily would have less cause for excitement than those placed in aquaria. For example, the aquarium fish has been removed from its natural surroundings, may have undergone changes in temperature, may have been placed in different water, and been handled more or less roughly in transit.

If the trapped fish in the wild accept captivity with little or no excitement, as was observed by Messrs. Clark and Varnox, it may be conjectured that they spend considerable time in idly swimming or in lingering in the middle of the net near the funnel opening. The captive might then escape by swimming through the funnel either by accident or by passing through purposely after seeing the opening.

If trapped fish are usually calm, conceivably they may be excited on occasions when the net is crowded or when large voracious species of fish or turtles are included among the captives. However, from experience in working with hoopnets, it may be said that ordinarily the fish within a net appear to be fairly "settled" until the fisherman grasps the net preparatory to lifting it into his boat. Only at that point is the charging of large fish against the sides of the net apparent.

EFFECTIVENESS OF THE FINGER-THROAT AS A HINDRANCE TO ESCAPES

The finger-throat is a device used on the inner funnel for the purpose of camouflaging the opening and further acts as a mechanical hindrance to exit. It may roughly be described as consisting of 2 half cones of twine, one on either side of the funnel mouth. The individual strings spaced an inch apart which make up the fingers are tied to a median string, which, in turn, is secured to the back hoop.

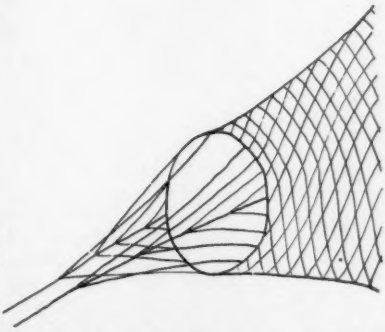

FIG. 2.—Sketch showing part of the rear hoopnet funnel with projecting finger-throat.

The design of the finger-throat is such that it is relatively inconspicuous to fish entering the funnel and thus has a minimum frightening effect. The lateral distance between the two halves of the throat is about 3 inches. When necessary the two halves may be forced apart to allow passage of fish of greater width. An examination of figure 2 will show why this device is not more effective in preventing the escape of fish caught in the rear compartment. Although it is apparent that the finger-throat would act as a barrier to fish approaching the mouth of the funnel from the side, it would seem to be relatively a much less effective barrier when the funnel is approached from directly in front or from slightly above or below the center of the opening.

EFFECT OF THE RATE OF ESCAPE ON HOOPNET EFFICIENCY

Usually hoopnets are raised at approximately one-day intervals. But for various reasons, the periods between raises may be stretched to two days or longer. On the basis of the above tests and from direct observations of Messrs. Clark, Varnox and Pace, it is clear that fish of certain species entering the hoopnets are not permanently confined but instead numbers of them will escape within a period of minutes or hours. Where the purpose of the fisherman is to catch the largest number of fish in the shortest time, there is thus an obvious advantage in raising the nets at frequent intervals in order to secure individuals which would otherwise escape.

Where hoopnets are used for quantitative evaluation of a fishery it would seem to be important to standardize the period of the set. In the past we have assumed that doubling the period of the set doubled the catch. As a general assumption this was doubtless not a valid one, although it might hold for certain species or under certain conditions.

A preliminary check on this matter as applied to a bluegill population was undertaken at Lake Glendale, March 25-31, 1944. We used six nets, of 1 inch mesh, set for alternate periods of one-day and two days so that the long and short sets were spread throughout the week in which the tests were made. During the week 17 one-day sets and 16 two-day sets were obtained. The one-day sets yielded 28.8 bluegills per net while the two-day sets yielded 38.8

bluegills per net. The two-day sets, therefore, yielded only 1.36 times as many bluegills as the one-day sets rather than twice the number. Presumably this ratio would vary with the species.

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NOTES ON THREE PSEUDOSCORPIONS FROM ILLINOIS

C. CLAYTON HOFF
Quincy College, Quincy

The present study, in which are given distribution records, ecological notes, and characteristics for species recognition relative to three very common species of Illinois pseudoscorpions, is the first of a contemplated series of papers based on material in the collections of the Illinois State Natural History Survey, the Chicago Museum, the Illinois State Museum, the American Museum of Natural History, and the writer's personal collection.

The pseudoscorpions, perhaps as a result of their small size and their seclusive habits, have long been a neglected group, those of Illinois being very poorly known. A single paper (Ewing, 1911) reports the presence of six species of pseudoscorpions from the state. Of the three species given in the present paper, only one, *Chelifer cancroides*, was reported by Ewing from Illinois. In the instance of this species, some of Ewing's records are in doubt since he used the species in a very wide sense and did not differentiate between it and some closely related species (Chamberlin, 1932).

Figures 1A and 1B

Chelifer cancroides (Linnaeus, 1761) L. Geoffroy, 1762

This nearly cosmopolitan species is the form commonly found in dwelling houses where it is said to prey upon bedbugs. The species is also found abundantly in granaries, stables, in beehives, and in the nests of swallows, sparrows, starlings, and pigeons. Out of the more than 125 collections of Illinois pseudoscorpions examined so far by the writer, *C. cancroides* has been found in only seven. This seemingly infrequent occurrence is easily explained by the fact that the majority of the writer's specimens have been taken from material in natural habitats of the state, and collections of *C. cancroides* are, as a result, more or less incidental. In six of the seven collections, habitat records are available. These include: grain in a barn, chicken house (individuals numerous), clothes on outdoor line, dwelling house, packing box, and an office. The distribution of the seven collections by counties follows: Adams Co. (2), Sangamon Co. (2), Cook Co. (1), St. Clair Co. (1), Champaign Co. (1).

Chelifer cancroides is noticed frequently as a result of its association with man and its relative large size, the male being 2.5 to 3.5 mm. long, the female 3.0 to 4.5 mm. This species can be separated from other pseudoscorpions so far observed in collections from the state by the very long pedipalps whose femur is about 5.3 times as long as wide and whose tibia is about 4.1 times as long as wide (fig. 1A). In addition, the tarsal claws (except those of the first pair of legs in the male) have split points (fig. 1B), a condition separating *C. cancroides* from other species with the same general body appearance.

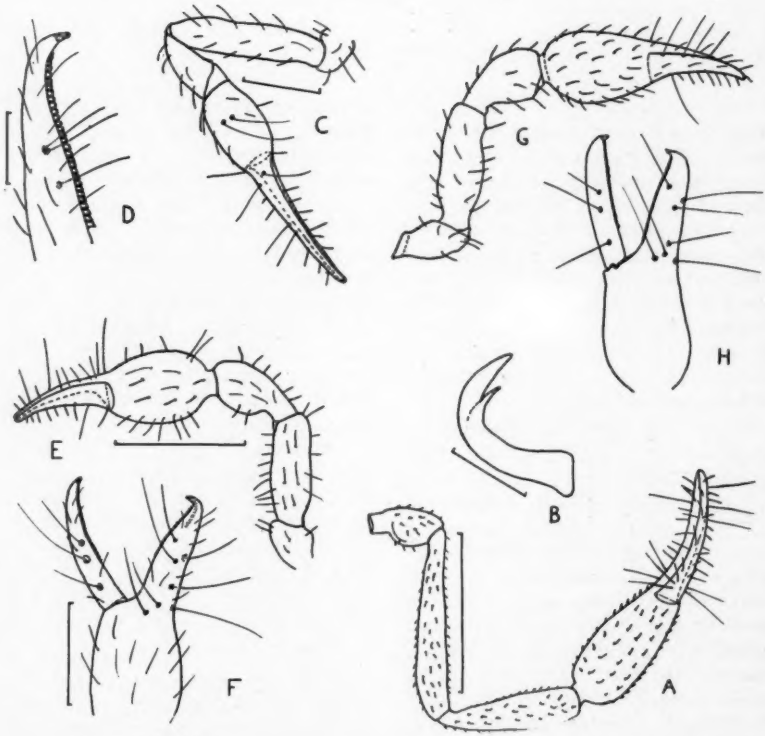

FIG. 1.—Drawings were made from material cleared in beechwood creosote and mounted in Canada balsam, except figures G and H which are redrawn from Chamberlin (1931). A camera lucida was used.

Chelifer cancroides, male. A.—Ventral view of right palp. Scale equals 1.0 mm. B.—One claw from fourth tarsus. Scale equals 0.05 mm.

Apochthonius moestus, female. C.—Dorsal view of palp. Scale equals 0.25 mm. D.—Interior view of tip of fixed finger. Scale equals 0.05 mm.

Microbisium brunneum. E.—Ventral view of palp. Scale equals 0.5 mm. F.—Exterior view of chela. Scale equals 0.25 mm.

Microbisium parvulum. G.—Palp from ventral side (redrawn from Chamberlin). H.—Chela from exterior to show shape of finger (redrawn from Chamberlin).

Apochthonius moestus (Banks, 1891) Chamberlin, 1929

Figures 1C and 1D

This frequently occurring species is found typically in the leaves and loam on the ground in the deciduous woods, as indicated by the fact that 17 out of 23 collections of this species were taken from this habitat. In some instances, individuals were found under the bark on logs or dead trees or in moss and lichens on trees or ground in the deciduous woods. One collection was taken from a mammal nest in the woods. While the species was found in numerous collections from the deciduous woods, it was not found in collections from the sphagnum of the tamarack swamps of the Chicago area. One individual of this species was found in a collection from leaf mold in Indiana Dunes State Park, Porter Co., Indiana (Chicago Museum collection).

Apochthonius moestus may be recognized by the small size, the light color, and the characteristics of palp and chela (fig. 1C). Of special significance in recognition of this species are the two tactile setae on the middorsal surface of the hand of the palp. As far as noticed, there is only one other Illinois species whose palp resembles that of *A. moestus*. In this instance, however, *A. moestus* may be recognized by examination of the teeth of the finger of the chela (fig. 1D). These teeth are contiguous and uniform in size and shape while the related species has teeth which are neither contiguous nor uniform.

The 23 collections of this species are distributed by counties as follows: Adams Co. (8), Pope Co. (1), Vermilion Co. (2), Jackson Co. (1), Clark Co. (7), Champaign Co. (1), Union Co. (1), Sangamon Co. (1), Menard Co. (1).

Microbisium brunneum (Hagen, 1869) Chamberlain, 1930

Figures 1E and 1F

This is by far the most common of all Illinois pseudoscorpions. It has been identified from 58 of the 126 collections so far examined from the state. Not only does the form appear in more collections than any other species but the number of individuals in each collection is greater. *M. brunneum* occurs in practically every kind of natural habitat from which collections have been made. The data indicate that the form has been collected more often from decaying leaves and loam in the deciduous woods than elsewhere, but this observation is probably more apparent than real as a high percentage of the present samples have been from the floor of the deciduous forest. Besides being found frequently in the loam and mold of the deciduous forest, the species occurs under and in partly decomposed logs, in rotten stumps, in mammal nests, and in moss. The form was also found in collections from grass sod, from rock ledges, and from rocky soil along railway tracks. The most interesting aspect of its ecological distribution, however, is an association with conifers especially in swamp and bog habitats. It was reported from the humus and soil in cypress bottoms in southern Illinois, from leaves beneath a juniper tree, and from a rotten pine stump. It is the common species of the sphagnum moss in the tamarack swamps or bogs of the Chicago area. The species appears well adapted to this last habitat since the number of individuals in many collections is much larger than the number of individuals in collections

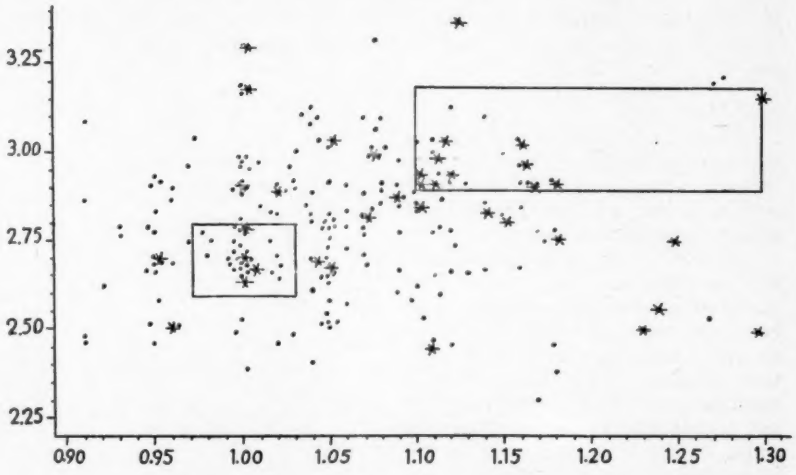

FIG. 2.—Scatter diagram showing the distribution of the palpal femur length/width ratio (along the vertical axis) and the finger-length/hand-length ratio (along the horizontal axis) of the chela of about two hundred individuals of *Microbisium brunneum* from Illinois. Individuals designated by asterisks are from a single Natural History Survey collection taken from sphagnum moss in a tamarack bog at Volo, Illinois. Other individuals are designated by dots and were selected at random from collections taken in all parts of the state. The small rectangle at the lower left indicates the limits of palpal femur length/width ratio and the limits of the finger-length/hand-length ratio as given in the literature for *M. parvulum*. The larger rectangle at the upper right shows the limits of the ratios as given in the literature for *M. brunneum*.

from the deciduous woods. In one collection from a tamarack bog, there were over 125 individuals; in another collection, over 35 individuals.

Because of the great diversity of habitat, *M. brunneum* has been found in nearly every locality in which adequate investigation has been carried out. Counties from which the species is reported and the number of collections from each county are as follows: White Co. (1), Adams Co. (10), Jo Daviess Co. (1), Cook Co. (2), Piatt Co. (1), Pope Co. (4), Champaign Co. (8), Lake Co. (11), Stephenson Co. (1), Jackson Co. (1), Vermilion Co. (2), Alexander Co. (1), Kane Co. (1), Mason Co. (1), Peoria Co. (1), Pulaski Co. (2), Clark Co. (6), Sangamon Co. (1), Ogle Co. (2), Logan Co. (1).

M. brunneum may be recognized by the small size of the body (less than 2.0 mm.) and by the shape of the chela (fig. 1E) which has only three tactile setae on the movable finger and seven tactile setae on the fixed finger (fig. 1F). So far as known at present, no other Illinois species has the chela shape and the reduced number of tactile setae found in this form. *M. brunneum* is, however, easily confused with *M. parvulum* (Banks, 1895) Chamberlin, 1930, which eventually may be found in the state.

Difficulty experienced by the writer in the recognition of *M. brunneum* and its separation from the

closely related *M. parvulum* led to a detailed study of the Microbisium species in the Illinois material. The writer found that, while all Illinois specimens appear to belong to a single species, some of the specimens possess characteristics which according to the literature identify them with *M. brunneum*, other individuals are typically of the species *M. parvulum*, while still more of the pseudoscorpions possess some characteristics of each of the species. The basis of separation of the two forms as given in the literature has been that the fingers are clearly longer than the hand (1.1 to 1.3 times as long) and the femur is 2.9 to 3.2 times as long as broad in *M. brunneum* while the fingers are subequal in length to the hand (0.97 to 1.03 times as long) and the femur is 2.6 to 2.8 times as long as broad in *M. parvulum*. The scatter diagram (fig. 2) shows the distribution of about two hundred Illinois individuals with respect to the length/width ratio of the femur and the finger-length/hand-length ratio of the chela. The limits of the ratios of these structures for *M. brunneum* and *M. parvulum* are indicated as given in the literature. From this graph, it is obvious that a single species of Microbisium is represented in the Illinois fauna. A study of the diagram leads to one of two conclusions: either (1) the two species, *M. brunneum* and *M. parvulum*, are morphologically inseparable and therefore a single species, or (2) the characteristics used are not satisfactory for the separation of the two forms.

In an attempt to determine definitely the Microbisium species occurring in Illinois and to demonstrate the true relationship between *M. brunneum* and *M. parvulum*, the writer examined a paratype of *M. brunneum* and one of *M. parvulum* loaned him through the courtesy of Mr. Nathan Banks of the Museum of Comparative Zoology. The examination revealed that beyond all doubt the Illinois material is identical with *M. brunneum* as described by Hagen. Measurements of the paratype of *M. brunneum* fall well within the limits set in the literature for the femur length/width ratio and for the ratio of the finger-length/hand-length. At the same time, the specimen of *M. parvulum*, although stored in alcohol and in poor condition for examination, was measured and results indicate that the ratios of the paratype are just at the lower limits of the ratios given for *M. brunneum* and do not fall within the limits given in the literature for *M. parvulum*.

It becomes clear, then, that the characteristics given in the literature for separation of *M. brunneum* and *M. parvulum* are not satisfactory. That the two are separate and distinct species, however, is obvious when one considers the shape of the palpal tibia, the chela, and its movable finger. Pseudoscorpions with the chela and finger shape of typical *M. parvulum* have not been observed as yet in Illinois collections. The chela of *M. parvulum* has a shorter pedicle, the line of demarkation between the pedicle and the margin of the hand on the exterior side is not so abrupt, and the hand is basally less tumid than is that of *M. brunneum*. The movable finger in *M. parvulum* is much straighter and distally more wide than the finger of *M. brunneum*. These and other differences are indicated in the original description by Banks (1895).

As a result of the study, it is apparent that: (1) *M. brunneum* and *M. parvulum* are not synonymous although a close morphological rela-

tionship is indicated; (2) *M. brunneum* shows an extreme amount of variation as might be expected from a species which occurs abundantly over a wide territory and which apparently reproduces parthenogenetically since no males are known to occur; (3) the two species of Microbisium under consideration cannot be separated on the basis of the ratio of femur length/width and the ratio of finger-length/hand-length as given in the literature; and (4) the two species may be separated by differences in the shape of the chela and movable finger.

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PICTINUS AURIVILLII BERG. IN ILLINOIS

WILLIS EVERETT SNOW
University of Illinois, Urbana

On September 16, 1943, while collecting insects from decaying debris in holes in trees, I found an adult female of *Pictinus aurivillii* Berg. This specimen was taken from a tree hole 12 feet above the ground in a living soft maple (*Acer saccharinum* L.) on the bluff near Edgemont, Illinois. The debris consisted of decayed leaves, wood, and mammal pellets.

The collection of this specimen in the St. Louis area provides a new distributional record for this species, proving its occurrence in Illinois and giving a much more northern extension than had previously been recorded. Other specimens of this species have been taken in the extreme south, at Crescent City, Florida, at Bayou Sara, Louisiana, and in Georgia, according to de la Torre Bueno (1939). Of the eight species in the genus, this is the only North American representative, the others occuring in South and Central America. Blatchley (1926) states that *aradids* have become strongly adapted by dorso-ventral flattening for life beneath closely fitting bark or in narrow crevices of wood. They are for the most part gregarious, living in small colonies composed of both nymphs and adults in various stages. When uncovered, they remain quiescent for a long time. In the northern states they hibernate both as adults and as nymphs, often sheltered only by bark. Although sometimes frozen for weeks, they revive when spring comes. Their food consists of minute fungi which occur within bark and in wood of trees and stumps. The tree hole, I believe, also may be important in the development of this species because fungi are abundant in tree hole debris and provide abundant food. The tree hole would also serve as an ideal shelter for hibernation in this latitude.

The female possesses a sharp well developed ovipositor which aids in the insertion of eggs beneath bark.

The fact that this hemipteran is so rarely encountered is due not only to its hidden position but also to its dusky color.

MEMORIALS

WESLEY PILLSBURY FLINT

Wesley Pillsbury Flint, Chief Entomologist of the Illinois State Natural History Survey and of the Illinois Agricultural Experiment Station, died suddenly in his office on June 3, 1943. He was born at South Hampton, N. H., May 4, 1883, and had passed his 60th birthday at the time of his death.

Wesley Flint obtained his undergraduate education at the University of New Hampshire. In November 1907, he was employed by the State Entomologist of Illinois and from that time on he lived in Illinois and worked in his chosen field of economic entomology. In 1917 he was appointed Economic Entomologist of the State Natural History Survey and was later made Chief Entomologist of the Survey and of the Illinois Agricultural Experiment Station, with the rank of professor.

In 1933, Professor Flint served as president of the Association of Economic Entomologists. He was a fellow of the Entomological Society of America and the American Association for the Advancement of Science. He was also a member of the Illinois State Academy of Science, Sigma Xi, and Gamma Sigma Delta. He served on many important national committees in the field of economic entomology. He was the author of many useful articles and bulletins dealing with the control of insect pests. With Professor C. L. Metcalf, he published the widely used text and manual entitled "Destructive and Useful Insects."

Professor Flint was, above all, a profound student of nature. He loved the out of doors and spent in the open every minute he could spare from his official duties, studying the habits of birds, insects, and wild animals. To him, love of nature was a religion.

During his 35 years in Illinois, he was influential in the conservation of natural resources, especially in having areas set aside by the state or by interested individuals for the preservation of wild life.

Professor Flint was the friend of hundreds of farmers in all parts of Illinois. When traveling over the state, he made a point of visiting them and always took a personal interest in their problems. He was held in high esteem by his colleagues of the Natural History Survey and University of Illinois staffs. Although he never served as a teacher, students sought his advice constantly, and he was influential in directing the research and careers of many of them.

—H. W. ANDERSON,
University of Illinois.

JAMES MARSHALL BRANNON

James Marshall Brannon was born at Lowell, Indiana, December 14, 1882. He died at Urbana, Illinois January 20, 1943. His sudden death was due to a heart attack.

Dr. Brannon graduated from the University of North Dakota with an A.B. degree in June, 1907; he received his M.A. degree from the University of Wisconsin in 1914, and his Ph.D. degree from Cornell University in 1920. His undergraduate work was done mostly in the fields of physiology, chemistry, and economics. His graduate work was in the fields of bacteriology, physiology, psychology and chemistry. He was a member of Sigma Xi and Gamma Sigma Delta. From 1909-1912 he served as an instructor in botany and physiology at the University of North Dakota. He also served on the North Dakota Geological Survey from 1907-1908. He was in charge of the North Dakota Biological Survey from 1912-1914 and was an assistant in limnobiology at the University of Wisconsin from 1914-1915. He served as an instructor in plant physiology at Cornell from 1916-1921, and became a member of the staff of the University of Illinois in 1922, where he served as assistant professor and assistant chief in Dairy Bacteriology until his death in 1943. Dr. Brannon has published studies of the carbonation of dairy products, the viability of Bacillus typhosis in ice cream, the utilization of sugar by plants, and the bacterial content of commercial gelatins. He also assisted in the invention of an electric water filter.

There probably have been few men on the faculty of the University of Illinois with broader training in the basic fields of science than J. M. Brannon. He was a constant reader of scientific books and kept close contact with the literature in the various scientific fields in which he was interested. Because of his wide knowledge and experience with biological subjects, he was often consulted by graduate students from various departments throughout the University. He was especially popular with the students majoring in Dairy Husbandry.

While in college, James Marshall Brannon participated in baseball and football, developing at that time an interest in sports that he maintained throughout life. He had wide community interests and a large circle of friends who will greatly miss the opportunity of discussing with him various phases of our economic, social, and industrial life for which he seemed so well qualified. Professor Brannon was a member of the Urbana Exchange Club and a member of the Episcopal Church of Champaign, Illinois. His loss to the

community and to the University is one which has been deeply felt by all who knew him.

—Paul H. Tracy
University of Illinois

WILL SAYER MOFFATT

Will Sayer Moffatt, M.D., died on September 12, 1941, at the age of 94, at Los Angeles, California where he had made his home since his retirement in 1927. He received the degree of Doctor of Medicine from the Hahnemaim Medical College, Chicago, in 1868. He seems to have begun his practice of medicine very soon after graduation, maintaining an office in Chicago and living at Wheaton, Illinois. He was an enthusiastic amateur botanist, making extensive collections throughout this Chicago region and associated with the late Dr. H. S. Pepoon in Jo Daviess County. His herbarium contained some 10,000 sheets of flowering plants which he donated to the Illinois State Academy of Science. The Academy in turn gave it to the University of Illinois where it is preserved at Urbana.

His "Higher fungi of the Chicago Region, Part 1; Hymenomycetes" was published in 1909 by the Chicago Academy of Sciences and was followed by "Higher fungi of the Chicago Region, Part 2; Gastromycetes" in 1923.

Dr. Moffatt joined the Academy in 1912, and in 1916 both he and his wife became life members of this organization. They were regular attendants of the meetings while they remained in Illinois.

—George D. Fuller.

ELMER KNEALE

Mr. Elmer Kneale, born June 21, 1884, deceased January 8, 1944, was both a Life Member and a Charter Member of the Academy. Although not a research investigator, Mr. Kneale was active in furthering the interpretation of science to the layman. For twenty-five years he directed one of the leading forum organizations in Illinois. In this capacity he made a unique contribution to community adult education in the Springfield area.

—Gilbert Wright.

ACADEMY BUSINESS

SECRETARY'S REPORT ON THE BUSINESS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

For the year May 8, 1943 to May 6, 1944

Compiled by LEO R. TEHON, *Secretary*
Illinois Natural History Survey, Urbana

In keeping with a recommendation made by the Committee on Publications and approved by the Academy Council on November 4, 1943, no issue of the Academy's Transactions is to be devoted, this year, to an account of the Academy business and committee reports. In keeping with the spirit of the recom mendation, and also for the purpose of making the greatest number of pages available for the technical contributions made by Academy members at the annual meeting, only abstracts of the Secretary's minutes are given below. Also, committee reports are reduced to the minimum or are omitted if no committee action was taken during the year. Full records on which the following account is based are part of the Secretary's file and are open to inspection by any Academy member, at the Secretary's office.

1. COUNCIL MEETINGS.

The customary four meetings of the Council were held during the year, all with President Lyell J. Thomas presiding.

At the first Council meeting, held at Jacksonville on May 8, 1943, the newly elected officers were introduced to their duties, the invitation of Northern Illinois State Teachers College, DeKalb, was accepted for the 1944 Academy meeting, and Dr. H. W. Gould was appointed Second Vice-President and Chairman of the Committee on Local Arrangements for the 1944 annual meeting.

At the second Council meeting, held at Urbana on November 4, 1943, reports were heard and approved from the treasurer, secretary, Committees on Local Arrangements for 1944, Membership, Teacher Training, and Publications, the Coordinator of the College Section, and the representative of the Junior Academy. Upon recommendation of the Committee on Publications, Miss Dorothy E. Rose, Urbana, was appointed Editor; also, recommendations were approved regarding publication of the transactions, to wit: (1) reduction to one issue per year, (2) discontinuation of the publication of abstracts of technical papers, (3) strict selection of papers for publication and publication of selected papers in their entirety, (4) elimination of extra page charges and editorial fees, strictly as wartime economy measures. Discussion of membership problems resulted in the Secretary's being instructed to submit, at the next Council meeting, a draft of constitutional amendments designed to improve the regulations regarding membership.

At the third Council meeting, held at Urbana on February 26, 1944, reports from the treasurer, secretary, and Junior Academy representative were heard and approved. A discussion of the facilities of the Science Aids services available at the Unviersity of Illinois, presented by Dr. Neil F. Garvey, resulted in Council approval of a science aid leaflet proposed for high school science units. A draft of amendments to the constitution, submitted by the Secretary, was discussed in detail, altered in certain respects, and ordered to be presented in constitutional manner for the vote of Academy members at the annual business meeting. Plans for the annual meeting were reviewed and the holding of a symposium on premedical education, also the possible organization of a section on human biology, were approved. In anticipation of the annual meeting, the President, with the advice of the Coun-

cil, appointed the following committees: *Committee on Nominations*, Alfred E. Emerson, chairman, A. R. Wanless, and Mrs. Audry Hill Linsley; *Committee on Auditing*, Walter Thomas, chairman, A. R. Buis, and James H. Sedgwick; *Committee on Resolutions*, Clarence Bonnell, chairman, T. H. Frison, and M. M. Leighton; *Committee on Necrology*, George D. Fuller, chairman, Harley J. VanCleave, and B. S. Hopkins. By unanimous vote, the Council suspended the Academy's regulations regarding the dropping from the membership list of members in arrears as to dues, in so far as those regulations would apply to members serving in the armed forces of the United States of America and to members absent from the continental United States in the performance of civilian duties related to the prosecution of the war.

At the fourth Council meeting, held at DeKalb on May 4, 1944, arrangements for the annual meeting were again reviewed, reports were heard from the treasurer, editor, Junior Academy representative, and the committees on premedical training, teacher training, and conservation. President Thomas summarized the year's progress of the Academy.

2. GENERAL BUSINESS MEETINGS.

The customary two Academy business meetings were held in connection with the annual meeting at DeKalb, on May 5, 1944. At the first meeting, called to order at 9:00 A.M. by President Thomas, public announcement was made of the appointments to committees on nominations, auditing, resolutions, and necrology, and President Thomas requested that reports from these committees be ready for the afternoon meeting.

At the second business meeting, held at 5:00 P.M., with more than 100 persons present, reports were heard from the treasurer, the auditing committee, the editor, and the librarian. The Committee on Research Grants reported the receipt of $201.50 as a grant fund from the American Association for the Advancement of Science and the awarding of this sum for 1944-45 as follows: (1) to Dr. C. L. Bieber, Department of Geology and Geography, North Central College, Naperville, for geological researches on the Decorah and basal Galena horizons, $50.00; (2) to Dr. C. C. Hoff, Quincy College, Quincy, to purchase microfilm copies of otherwise inaccessible papers in connection with a study of pseudoscorpions, $50.00; (3) to Dr. W. Malcomb Reid, Department of Biology, Monmouth College, Monmouth, for material to study *in vitro* and *in vivo* behaviors of nematodes, using baby chicks as hosts and culture material, $51.50; (4) to Dr. Walter B. Welch, Southern Illinois State Normal University, Carbondale, to study healing of wounds in apples, using plant hormones of the "stop drop" type, $50.00. Resolutions offered by the Committee on Resolutions were adopted by vote and are printed below. The Committee on Necrology, without report, furnished the obituaries of deceased members printed in this issue of the Transactions. Amendments to the constitution and by-laws of the Academy, previously mailed to the membership of the Academy, were discussed and adopted by unanimous vote; they are printed below. The Committee on

3. REPORTS OF THE TREASURER AND THE COMMITTEE ON AUDITING

(a.) REPORT OF THE TREASURER FOR THE YEAR MAY 1, 1943 TO APRIL 30, 1944

Receipts

Balance on hand April 30, 1943		$1,274.91	
Dues and initiation fees:			
Annual members	$690.10		
Affiliated societies	2.00	692.10	
Editorial and excess pages fees		94.00	
Research grant from the A.A.A.S.		210.50	
Libraries		4.00	
Interest from Forbes and Meyer real estate		18.00	
Junior Academy:			
Dues	35.80		
Sustaining members	240.00	275.80	
TOTAL RECEIPTS		$2,569.31	$2,569.31

Expenditures

Officers' expenses	$ 50.43		
Section chairmen's expenses	84.28	$ 134.71	
Postage, treasurer's office		16.90	
Postage and transportation, *Transactions*		33.70	
Printing of Transactions		377.85	
Expenses of Secretary		91.94	
Secretarial help		25.00	
Lectures at 1943 annual meeting		61.48	
Expenses of editor		7.00	
Corporation registration (required by law)		2.00	
Research grants:			
C. L. Bieber	165.00		
C. M. Bennett	45.50	210.50	
Secretary, honorarium		150.00	
Editor, honorarium		150.00	
Junior Academy:			
Officers expenses	10.29		
Pins	84.70		
Diplomas	21.35		
Science Aids	35.00		
Printing and postage	22.57	173.91	
TOTAL EXPENDITURES		$1,434.99	$1,434.99
BALANCE ON HAND APRIL 30, 1944, on deposit in the Commercial Merchants National Bank and Trust Company, Peoria, Illinois		$1,134.32	$1,134.32
			$2,569.31

Respectfully submitted,
(Signed) JOHN VOSS, *Treasurer.*

(b.) REPORT OF THE COMMITTEE ON AUDITING.

May 2, 1944

Illinois State Academy of Science,
Mr. John Voss, Treasurer,
Peoria, Illinois.
Dear Sir:

We are pleased hereby to certify that the books of this Bank, at the close of busines April 30, 1944, showed the following balance, subject to check, at the credit of the ILLINOIS STATE ACADEMY OF SCIENCE: $1,134.32.

Very truly yours,

(Signed) J. W. LUKE, *Cashier,*
Commercial Merchants National Bank and Trust Company of Peoria.

Committee on Auditing,
(Signed) WALTER W. THOMAS, *Chairman*
JAMES H. SEDGWICK
A. R. BUIS.

May 3, 1944.

The Illinois State Academy of Science,
L. R. Tehon, Secretary.
Gentlemen:

This is to certify that we have examined the accounts of the Treasurer of the Illinois State Academy of Science for the year May 1, 1943 to April 30, 1944 and find them correct.

Committee on Auditing,
(Signed) WALTER W. THOMAS, *Chairman,*
JAMES H. SEDGWICK
A. R. BUIS.

Nominations presented a slate of officers, delegates, committee chairmen and committee members which, with no additional nominations suggested from the assembly, was unanimously elected; the list appears at the beginning of this volume.

4. REPORT OF THE LIBRARIAN.

Surplus copies of *Transactions* issued during the year have been received by the Librarian from the printer and stored with other back volumes. By action of the Council these publications are now available to members and non-members alike upon payment of $1.00 per annual volume plus delivery charges, this fee being payable to the Treasurer. Scientific societies and Libraries sending publications in exchange are supplied with back issues without charge where a reciprocal service is rendered.

Through further action by the Council, the Librarian was authorized to unstaple or mutilate a limited number of the surplus *Transactions* for the purpose of promptly meeting requests for single papers by war research or industrial organizations. The expense in this matter has been very slight, since a single issue may fill a variety of needs.

One scientific society, the Connecticut Academy of Science, was added to the exchange list during the year.

Respectfully submitted,

(Signed) GILBERT WRIGHT, *Librarian.*

5. AMENDMENTS TO THE CONSTITUTION AND BY-LAWS ADOPTED MAY 5, 1944.

Article VII, paragraph 3, of the Constitution is amended to read as follows: All members shall, except in case of emergency, receive without cost to themselves the currently published *Transactions* of the Academy, but no member in arrears shall receive the published *Transactions* of a ny year for which he is or remains in arrears.

Article V of the By-laws is amended to read: Members who, after having been duly notified by the Treasurer, shall fail to pay their dues by December 31st of any year shall be considered in arrears and shall have their names stricken from the membership roll. (*Note: By former action of the Council (Transactions, vol. 14, p 9) the fiscal year of the Academy begins with the calender year and dues are payable on the December 1st preceding.*)

Article V of the By-laws is further amended by the addition of the following paragraph: Persons formerly members of the Academy may be reinstated as members without the payment of an initiation fee, provided application for reinstatement is made not later than three (3) years after the termination of the former membership. Such members may obtain the printed *Transactions* for the intervening non-membership years upon payment of one dollar for each such year and the cost of mailing the *Transactions.*

6. RESOLUTIONS REPORTED BY THE COMMITTEE ON RESOLUTIONS AND ADOPTED BY VOTE.

(a.) RESOLUTIONS WITH RESPECT TO WAR AND NATURAL RESOURCES.

WHEREAS, the present war has of necessity made appalling inroads on the reserves of our exhaustible natural resources including a variety of minerals, groundwater, and soil elements; and

WHEREAS, these natural resources form a part of the basis for the future welfare of humanity and must be husbanded to serve man's normal needs throughout time to come; and

WHEREAS, the reserves of some of these resources have been so diminished by this war that another war would threaten complete exhaustion of them; and

WHEREAS, the Government of the United States will, we trust, soon face the opportunity of participating in the shaping of peace terms which will help determine the length of time that peace can be maintained in the future; and

WHEREAS, it is proper that scientific organizations such as the Illinois State Academy of Science express themselves upon matters of public policy such as these; therefore,

BE IT RESOLVED, that the Illinois State Academy of Science set forth and emphasize the grave importance of a wise peace that will have as its primary objective the prevention of future wars and the consequent waste of natural resources essential to human welfare; and

BE IT FURTHER RESOLVED, that the Illinois State Academy of Science

declare its hope that the Government of the United States of America will take a courageous and far-sighted position at the peace table that will result in wise and effective measures for the preservation of international peace through generations to come; and

BE IT FURTHER RESOLVED, that copies of this resolution be sent to the President of the United States, the Secretary of State, the United States Senate, the Speaker of the House of Representatives and the members of the Senate and House from Illinois, and to the President of the American Association for the Advancement of Science, and that a copy of this resolution be spread upon the Minutes of the Academy.

(b.) RESOLUTIONS WITH RESPECT TO TEACHER TRAINING.

WHEREAS, the minimum academic requirement for the preparation of teachers of the sciences in Illinois secondary schools is too low and should be raised; and

WHEREAS, this can be accomplished by revision of the bulletin *The Recognition and Accrediting of Illinois Secondary Schools;* and

WHEREAS, the responsibility for the rewriting of the said bulletin rests with the University of Illinois' Committee on Admissions and the Office of the State Superintendent of Public Instruction; therefore

BE IT RESOLVED, that the Illinois State Academy of Science approves the following recommendations of its Committee on Teacher Training, to wit:

1. No teacher should be certified to teach any subject in any Illinois secondary school without a minimum of two years college preparation in that subject (a minor of 16 semester hours);

2. For those subjects, now taught in the secondary schools, which cover two or more great fields of knowledge, equal preparation for each of the major fields should be required. For example: high school biology should have a minor in botany and a minor in zoology (including physiology); high school physical science should have a minor in chemistry and a minor in physics. This should be considered as minimum preparation;

3. For general science each teacher should be trained in at least three of the major sciences (more if possible) and have a minor in one of the major sciences;

4. Each teacher should have a major in his special field of science and at least a minor in the related science and a second minor in another related science: for example, a chemistry teacher should have a major in chemistry, a minor in physics, and a second minor in mathematics or botany and zoology or other subjects elected by the student;

5. These requirements should be enforced for the teaching of other subjects in the secondary schools as well as for the teaching of science;

BE IT FURTHER RESOLVED, that the Illinois State Academy of Science transmit copies of this resolution to the State Superintendent of Public Instruction, the University of Illinois' Committee on Admissions, and to the University of Illinois' Committee on the Training of Teachers for the Secondary Schools.

(c.) RESOLUTION EXPRESSING APPRECIATION FOR FACILITIES EXTENDED IN CONNECTION WITH THE THIRTY-SEVENTH ANNUAL MEETING OF THE ACADEMY.

WHEREAS, Northern Illinois State Normal College, its President, Dr. Karl L. Adams, its faculty, and particularly the local arrangements committee consisting of H. W. Gould, chairman, C. E. Montgomery, G. L. Terwilliger, W. H. Beaumont, L. T. Caldwell, W. C. Gould, I. J. Jenks, Miss Celine Neptune, C. E. Howell and J. R. Hainds, have made possible, under the difficult conditions imposed by a nation at war and a community immersed in the production of war materiel, the holding of an outstandingly successful annual meeting of the Academy, with every facility provided for the convenience and comfort of the Academy members; therefore,

BE IT RESOLVED, that the Illinois State Academy of Science hereby expresses its deep appreciation of the manifold efforts expended in its behalf and of the innumerable courtesies rendered toward its members; and

BE IT FURTHER RESOLVED, that a copy of these resolutions be tendered each of the persons named above and that this resolution be spread upon the Minutes of the Academy.

7. REPORT OF THE COLLEGIATE SECTION.

The meeting of the Collegiate Section at DeKalb, Friday afternoon, May 5, 1944, included the presentation of 12 of the 15 papers which were announced in the program and program supplement. Papers numbered 1, 3, and 6 of those listed were not presented. Miss Florence Kirchner of Northern Illinois State Teachers College, and Miss Betty O'Connor of the College of St. Francis, Joliet, served as co-chairmen. The meeting was well attended, with an average of about 40 and a maximum of about 50 present. The Council of the Collegiate Section for the next year will consist of ten students representing the 9 colleges participating in the DeKalb meeting, and Illinois State Normal University, the host school for the 1945 meeting. The continued interest in the Collegiate program during years when college scientific research is reduced to a minimum indicates that in postwar times this group will probably expand to include separate meetings in several of the sciences. The papers presented this year came from eight colleges, and included work in the following fields of science: geology, physiology, mathematics, chemistry, physics, zoology, dietetics, and medicine.

(Signed) H. R. WANLESS, *Coordinator.*

8. REPORT OF THE COMMITTEE ON AFFILIATIONS.

The principal activity of this committee for the year consisted of writing to college science teachers through the state, suggesting the affiliation of science groups, societies, or other clubs with the Academy. Two groups affiliated, (1) College Science Club, Le Clerc College, Belleville, with Sister M. Joecile as Moderator, and (2) Wasmann Loyola Chapter, Charles J. Wideman, Chairman, of Loyola University, Chicago.

The present seems to mark a low ebb in the activity of scientific organizations in the colleges and universities, and the same is probably true for community science associations. Very likely several of the affiliated science groups are now inactive due to the war, and I believe that their names should be kept on the list of affiliated societies for the duration, and energetic effort made to renew their active cooperation when they resume their own activities after the war.

(Signed) H. R. WANLESS, *Chairman.*

9. REPORT OF THE COMMITTEE ON ECOLOGICAL BIBLIOGRAPHY.

(a.) THE LITERATURE OF ILLINOIS NATURAL HISTORY AND GEOGRAPHY, BY A. G. VESTAL.

This report appears on pages 63-65 of this volume.

10. REPORT OF THE COMMITTEE ON PREMEDICAL EDUCATION.

This committee was active throughout the year, holding several meetings, the complete minutes of which are on file with the Secretary, and sending out questionnaires bearing upon the business of the committee. To the faculties of the five principal medical schools, 898 questionnaires were sent, and a return of 457, or 51 per cent was obtained. To the students of the same schools, 1,529 questionnaires were distributed and 586, or 39 per cent, were returned. The answers given in the returned questionnaires were tabulated and considered at a meeting of the committee on April 22, 1944. At that meeting a motion was passed that the matter of the foreign language requirement be referred to a subcommittee for further study. Also, the following general conclusions were approved at the meeting:

1. That the committee must devise ways and means of bringing closer correlation between medical and premedical teachers and students, such as through regional conferences within the state.

2. That the committee, in accordance with results from the faculty questionnaire, favor the requirement for more liberal arts subjects in the premedical program.

3. That the work of the committee should be continued and that more of its personnel be from the premedical field.

4. That a short summary of the committee's work be presented to the American Association of Medical Schools.

5. That a statement of the work and progress of the committee be prepared and submitted to the public through the pages of Science.